Engineering News

VOLUME 74 DECEMBER 23, 1915 NUMBER 26

Pike's Peak Highway, Colorado

By R. C. Hardman*

What is claimed to be the world's highest automobile highway has recently been completed from Cascade, Colo., to the summit of Pike's Peak. Pike's Peak, which attains an elevation of 14,109 ft. above sea level, is perhaps the best known and most visited mountain in the United States. Although there are some 26 mountains and peaks in Colorado alone which are higher than Pike's, it, by virtue of its dominant position in the Rampart Range and its easy accessibility, ranks first in the mind of the tourist. Since the construction of an Abt-system cog railway (Manitou & Pike's Peak R.R.) in 1891 thousands of tourists have made the ascent to the summit, from which it is said some 60,000 sq.mi. of the State of Colorado can be seen. A makeshift carriage road has also been available for a number of years, but only very few automobiles have been able to reach the top.

The Peak is located about 14 mi. west of Colorado Springs. The base of the Peak is at Manitou, about 6 mi. northwest of Colorado Springs, the cities being connected by an electric railway. The ascent of the Peak is made from Manitou by cograil railway or burro. The cog road is approximately 9 mi. long, having an average grade of about 16%, with a maximum of 25%.

FIG. 1. VIEW LOOKING OVER A PART OF THE PIKE'S PEAK HIGHWAY

*Civil Engineer, Colorado Springs, Colo.

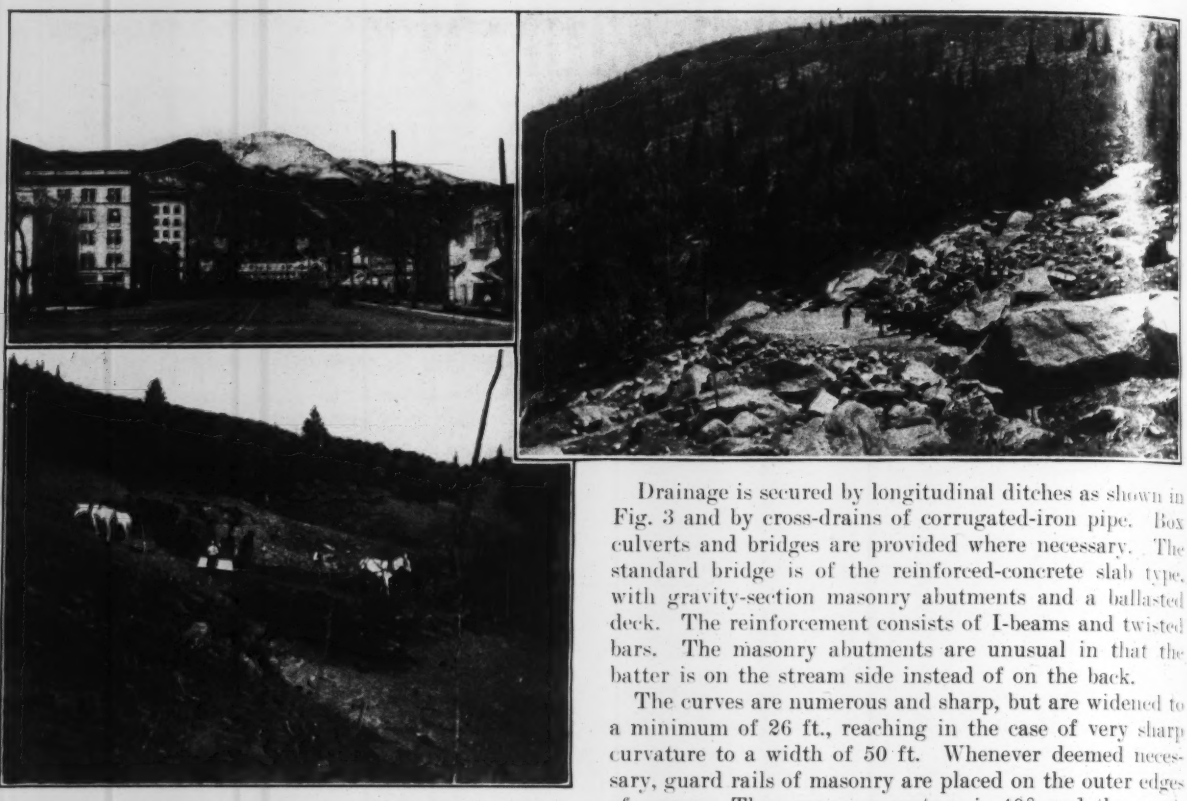


FIG. 2. PIKE'S PEAK FROM COLORADO SPRINGS: CONSTRUCTION VIEWS OF NEW AUTOMOBILE HIGHWAY

About a year ago a company was organized to construct and operate a toll road to the summit. The most feasible route was found to be that of the old carriage road which branches off the Ute Pass state highway at Cascade, about 12 mi. northwest of Colorado Springs in the historic Ute Pass, on Fontaine qui Bouille Creek. Surveys were made early last spring, and the construction work followed closely. The line of the old carriage road was followed in general, although the new line was relocated throughout its entire length, attention being given to the scenic possibilities. Typical of mountain highways, it abounds in sharp curves and steep grades.

Starting from Cascade at an elevation of 7,415 ft., the new road reaches the summit of the Peak in 17.9 mi., rising in elevation 6,694 ft. The road first climbs Cascade Mountain, following Cascade and Crystal Creeks, then traverses Crystal Creek plateau, skirts the Rampart Range, the crest of which is reached at about Mile 15. From there to the Peak, 2.9 mi., the road rises from El. 12,970 to El. 14,109. The timber line is reached at about Mile 12 at El. 11,880.

The engineering features, while not unusual, differ in many ways from the older mountain roads of Colorado, many of which are not wide enough for two vehicles except at intervals where turnouts are provided. The standard width of roadway adopted is 20 ft., of which 3 ft. is used as a shoulder and to form a shallow drainage ditch for all cross-sections except on embankments. On embankments the roadway cross-section is a parabolic curve with a crown of 0.3 ft. On sidehill cut-and-fill cross-sections the surface has a transverse slope of 1 in 40. Typical cross-sections are shown in Fig. 3.

Drainage is secured by longitudinal ditches as shown in Fig. 3 and by cross-drains of corrugated-iron pipe. Box culverts and bridges are provided where necessary. The standard bridge is of the reinforced-concrete slab type, with gravity-section masonry abutments and a ballasted deck. The reinforcement consists of I-beams and twisted bars. The masonry abutments are unusual in that the batter is on the stream side instead of on the back.

The curves are numerous and sharp, but are widened to a minimum of 26 ft., reaching in the case of very sharp curvature to a width of 50 ft. Whenever deemed necessary, guard rails of masonry are placed on the outer edges of curves. The average curvature is 40° and the maximum is 96°. On several of the sharper curves where it was not feasible to use the standard cross-sections, special cross-sections were designed. One of these, at the summit, is shown in Fig. 3. The extremely crooked alignment of the road is shown in Fig. 4. To further show the method of handling the "switchbacks" necessary to make the climb in Miles 14 and 18 enlarged plans are given in Figs. 5 and 6. In Mile 14 an elevation of 455 ft. is overcome. The average grade of the highway is a trifle over 7%.

The maximum grade is 10%. There are few adverse grades. Fig. 7 shows a condensed profile, with the vertical scale ten times the horizontal. The elevations at the mile posts only are used in making this profile, so that the grades shown are average and not the steepest.

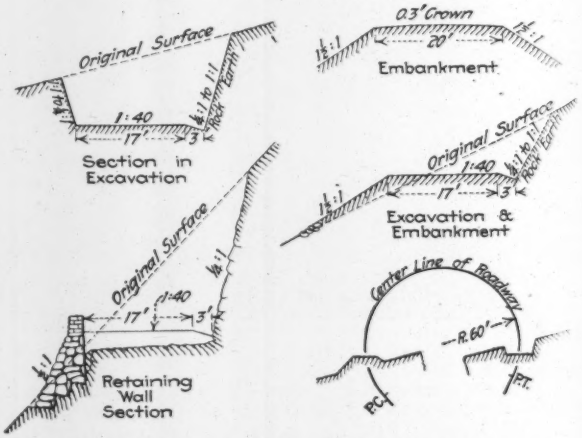
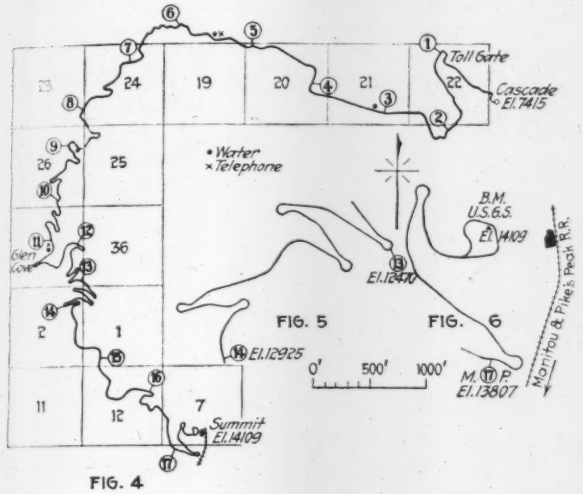


FIG. 3. TYPICAL SECTIONS IN CUT AT RETAINING WALL AND SECTIONS AT THE SUMMIT LOOP

Automobile supply stations are provided along the road. One of these is located at Toll Gate, one at Glen Cove and a third at the summit of the Peak. Water-supply tanks and hose are located as shown on the plan, Fig. 4. A telephone line 12½ mi. in length also reaches from Cascade to the top. The company which built the road



FIGS. 4, 5 AND 6. PLAN OF PIKE'S PEAK AUTOMOBILE TOLL ROAD AND PLANS OF MILES 14 AND 18

operates a number of tourist motor cars. Privately owned cars are also allowed to use the road on payment of toll.

The photographs show the country through which the highway is built, although due to the lack of perspective full justice is not done the magnificent scenery. The material of which the road is built, in common with that of all the Pike's Peak region, is mostly granite and disintegrated granite. In some places a light surface soil was encountered. No special difficulty in construction was experienced, although part of the road is in a region

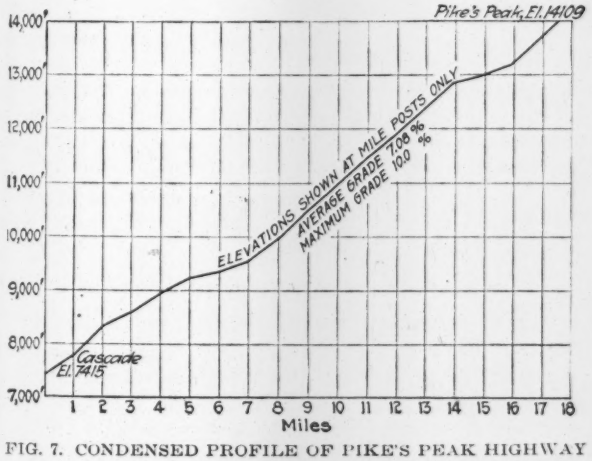


FIG. 7. CONDENSED PROFILE OF PIKE'S PEAK HIGHWAY

of perpetual snow. No power machinery was used for grading. The material was moved by hand shoveling, slip, fresno and wagon, as is usual in the West.

The originator and proprietor of the road is E. A. Sunderlin, of Colorado Springs, Colo. The location and design were under the direction of A. G. Allan, of Denver, as Chief Engineer. The writer wishes to acknowledge the courtesy of N. L. Drew, of the company, in furnishing much of the data given.

Sewage Disposal at Detroit

The problem of sewage disposal at Detroit, to eliminate the present pollution of the Detroit River, is complicated by the fact of the river being an international stream, the prevention of the pollution of which is under investigation by an International Joint Commission. In December, 1914, Clarence W. Hubbell, consulting engineer, was appointed by the city to investigate the problem and make recommendations for its solution. His work is being carried on independently of but in close relation with that of the commission.

For some years past Detroit has been growing at a more rapid rate than any other city in the United States. It has now a population of about 780,000, including immediate suburbs, and it is estimated that it will reach 1,500,000 in the 1935-45 decade. It has the combined system of sewers, with numerous outlets along the river In this way it pollutes the water of several lower towns.

The city water-works intake is just above the upper sewer outfall, at the Fairview sewage-pumping plant, which is to be enlarged. But the water is already polluted by villages and towns higher up along the shore of Lake St. Clair. Some of these places are building sewerage systems (on the separate plan), and by agreement with them the city has built and expects to extend an intercepting sewer near the shore line to protect the city's water-supply. The water is treated by hypochlorite, but this is to be changed to liquid chlorine.

The highest pollution is below the city on the American side (max. 100,000 B. coli per 100 c.c.), a lower pollution (max. 10,000) on the Canadian side, and relatively low pollution (4 to 10) in the middle of the stream, except that occasional high records (100 or more) in the middle indicate pollution from ships.

The general plan will include large areas that can be successfully handled only by establishing a sanitary district or by extending the city limits to include rapidly developing suburbs. The conversion of the city's sewers from the combined to the separate system will not be recommended except where feasible in new territory. Tentative plans provide for the construction of intercepting sewers to handle the sewage proper and deliver it to treating plants (probably Imhoff tanks or screens, combined with disinfection). Industrial wastes do not present any serious difficulties except that grease and gasoline from the large automobile factories constitute a special problem, and means must be taken to prevent explosions in the sewers and pumping stations.

The instructions issued by George H. Fenkel, Commissioner of Public Works, to Mr. Hubbell cover three principal points: (1) To review the data and conclusions of the International Joint Commission for the purpose of enlarging on any phase of the matter necessary in order to determine what preventive or remedial measures are required with reference to Canadian waters. (2) To what extent does the Detroit sewage pollute American waters so as to render them unfit as a source of raw water for filtration purposes? (3) The means which the city should undertake to purify the sewage, and what expense would be justifiable for that purpose.

The report will be broad and comprehensive, giving general plans, estimates and recommendations, but leaving the preparation of detail plans until action has been taken on the general recommendations.

Sand and Gravel Washing and Grading Plant

By C. B. Breed*

The use of gravel for concrete is well established, and as pit gravel contains usually an excess of sand, it is now general practice to clean and grade these materials by screening and washing. An advantage to the contractor is that the gravel and sand can be shipped from the same pit, so that there is less liability of delay or interruption in the supply of concrete material.

A sand and gravel washing plant recently built at Lynnfield, Mass., is shown in Fig. 1. This has a capacity of handling 800 cu.yd. of pit gravel per 8-hr. day. The material is excavated by means of a dragline cableway with a 2-yd. bucket. A 1⅜-in. track cable passes over a tower 122 ft. high and has one end anchored to a deadman in the pit, while the other end (beyond the tower) is attached by a follower tackle and blocks to an anchorage cable leading to another deadman.

Operating the Dragline Excavator

A traction cable hauls the bucket at a speed of 250 ft. per min. while excavating and 600 ft. per min. while running from the pit to the top of the tower. For raising and lowering the bucket, the sag of the track cable is changed by means of the follower tackle. The two

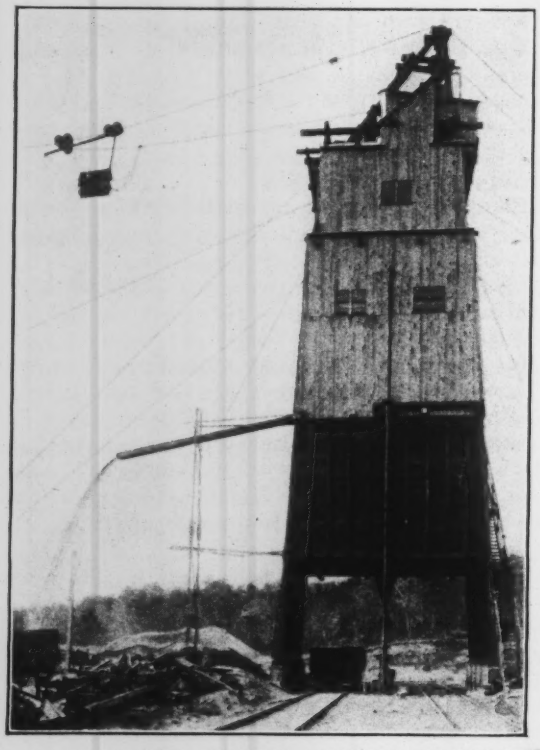


FIG. 1. SAND AND GRAVEL WASHING PLANT WITH DRAGLINE BUCKET EXCAVATOR

operations of raising and lowering the bucket and hauling it to and fro are accomplished by two drums in the tower—a two-speed drum for the traction cable and a one-speed drum for the follower. These are driven by a 75-hp. slip-ring electric motor. A 5-hp. motor in the tower drives an air compressor of the type used on electric cars, the air operating the pneumatic friction control of the traction-cable drums.

The bucket is suspended from the cable by two double sheaves running on the main cable. The forward one

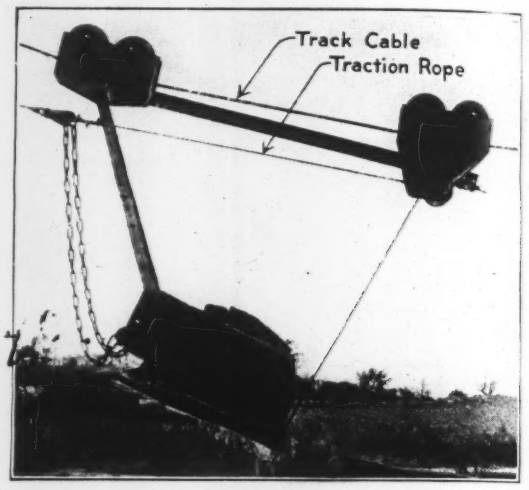


FIG. 2. DRAGLINE BUCKET, SHOWING TROLLEYS AND CABLE CONNECTIONS

is attached to the bail of the bucket and also to the end of a 6-ft. I-beam which passes through (but is not attached to) the rear sheave (Fig. 2). When the empty bucket is returning by gravity from the tower, these sheaves are at the opposite ends of the I-beam, and the bucket is balanced so as to be in digging position as it travels back to the excavation. During the digging process the pull is on the bridle chains attached at the front corners of the bucket.

When the loaded bucket is being pulled back to the tower, the strain is on an extension of the traction cable which passes over a small idler sheave in the rear sheave and is attached to the back of the bucket. As it reaches the tower, the front sheaves come in contact with a stop on the supporting cable and further pulling on the traction cable raises the back end of the bucket and thus accomplishes the dumping. This device requires no latches, and the dumping is effected automatically and rapidly. The average rate of operation is 45 round trips of the bucket per hour.

Screening and Washing the Material

The arrangement of the screens and bins is shown in Fig. 3. The gravel dumped into the hopper passes over a grizzly, or bar screen, which permits all material of less than 2-in. size to pass through onto the top one of four nearly horizontal shaking screens, as shown. The sizes of the round holes in the screens are such as to separate the materials into the following sizes: 2- to ⅜-in. for mass concrete, 1- to ⅜-in. for reinforced concrete, ⅜- to $\frac{3}{16}$-in. for roofing gravel, $\frac{3}{16}$- to ⅛-in. for granolithic sand, and everything below ⅛-in. for building sand.

The oversize material runs over the grizzly bars into a hopper and thence to a crusher, after passing which it is delivered to the top deck of the horizontal screens. Any material that does not pass through the top screen

*Consulting Engineer, 6 Beacon St., Boston, Mass., and Professor of Railroad Engineering at the Massachusetts Institute of Technology.

(being over 2-in. size) passes off at the lower end of the screen into a chute feeding a bucket elevator which dumps it again into the crusher hopper.

When the material falls on the top screen, it is deluged with water delivered by a 25-hp. centrifugal pump running at 1,800 r.p.m. and delivering 1,000 gal. per min. The water passes through all four screens, thoroughly washing the materials and carrying with it into the settling tank everything less than ⅛ in. in size. A flight conveyor operates through this settling tank and pushes the sand forward to the high end of the tank, at the same time washing it and forcing it finally over the edge of the tank into the chute leading to the proper bin. The loam and other objectionable material pass off in suspension in the dirty water which flows over the lower end of the tank. The crusher, elevator, screens and flight conveyor are all operated by a 75-hp. electric motor.

The material retained on the various screens passes off their ends and falls into metal chutes which run to the proper storage bins below. In these chutes are tipples which permit of diverting the materials in such a manner as to make it possible to mix various sizes as

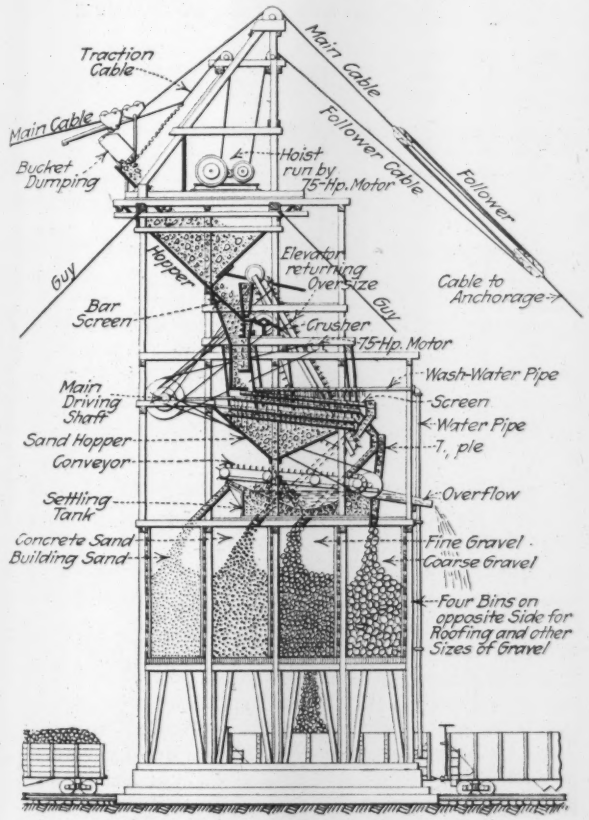


FIG. 3. SECTIONAL ELEVATION OF SAND AND GRAVEL WASHING PLANT AT LYNNFIELD, MASS.

they pass from the screens and so fill a bin with a mixture of sizes if required. Flush gates operated by hand levers allow the material in the bins to drop directly into railway cars beneath.

Excavation can be made as readily under water as in the dry, as the operator in the tower can tell from the load on the engine whether the bucket is being filled. As the excavation proceeds a trench is dug between points as near the deadman and the tower as seems safe, and to the full depth of the material. It is customary to bury a pair of deadmen about 150 ft. apart at the end of the track cable, and to attach the cable to one of these. Blocks and tackle are rigged from the cable to the other deadman, so that the line of the cable can be shifted about 75 ft. without shifting the anchorage on the other side of the tower or bringing excessive strain on the top of the tower.

This permits a wider trench to be excavated than would be possible if the main cable ran directly to one anchorage. When the trench has been excavated the two deadmen, one at each end of the cable, are moved, say, 150 ft. from their old position and a new cut is begun. The entire top of the tower above the hopper is built on a turntable, which is turned as the line of the cable is changed.

Storage and Shipping

The plant is operated by five men—one at the engine in the tower, one at the crusher, one at the screens and two repairing, cleaning and loading the cars.

In addition to the bin storage, provision has been made for ground storage of 100,000 tons of washed and graded materials. These materials are loaded on cars at the rate of 1,000 tons per day by means of a 15-ton steam-driven locomotive crane equipped with a 1-yd. clamshell bucket swung from a 50-ft. boom. The crane operates on standard-gage tracks and may be used when necessary for shifting the freight cars. The tracks, however, are on a grade so that the cars can be dropped by gravity under the bins, receive their load and pass along by gravity to the storage tracks beyond.

From this 122-ft. tower the cables can be stretched so as to permit excavation to be made at a distance of 1,300 ft., giving an available area of ½-mi. diameter before it becomes necessary to move the tower to another site. If the material is 20 ft. deep it will take 12 years of continuous operation before a plant of this capacity would have to be moved. The plant has a bin capacity of 1,300 tons and a daily production capacity of 1,000 tons. The material is a well-graded angular sand and a subangular glacial gravel; very little oversize material has been encountered.

This plant was designed by the Cable Excavator Co., of Philadelphia, Penn., and was built under the direct supervision of its Vice-President, A. D. Hadsel, who is also the inventor of the excavating bucket described. The plant is owned and operated by the New England Sand and Gravel Co., of West Peabody, Mass., the writer serving as consulting engineer for this company.

Progress of Second Simplon Tunnel—The latest report for the second Simplon Tunnel shows that the tunnel is over half-completed, the figures of completed tunnel at the end of October, 1915, being 29.9% for the south end and 25% for the north end, a total of 54.9%, according to the "Schweizerische Bauzeitung." The respective lengths are 19,431 ft. (5,924 m.) and 16,242 ft. (4,952 m.), a total of 35,673 ft. (10,876 m.). At each end four or five hundred feet more of top heading and excavation work has been done. The work accomplished during October amounted to 774 ft. (236 m.) of completed tunnel at the south end and 157 ft. (48 m.) at the north end, a total of 931 ft. (284 m.). This was accomplished with a working force in the tunnel of 628 and 90 for the two ends respectively, and outside the tunnel 212 and 79, making a total working force of 1,009. During recent months the work has been very seriously hampered by continual change of forces on account of the military draft of Italian laborers.

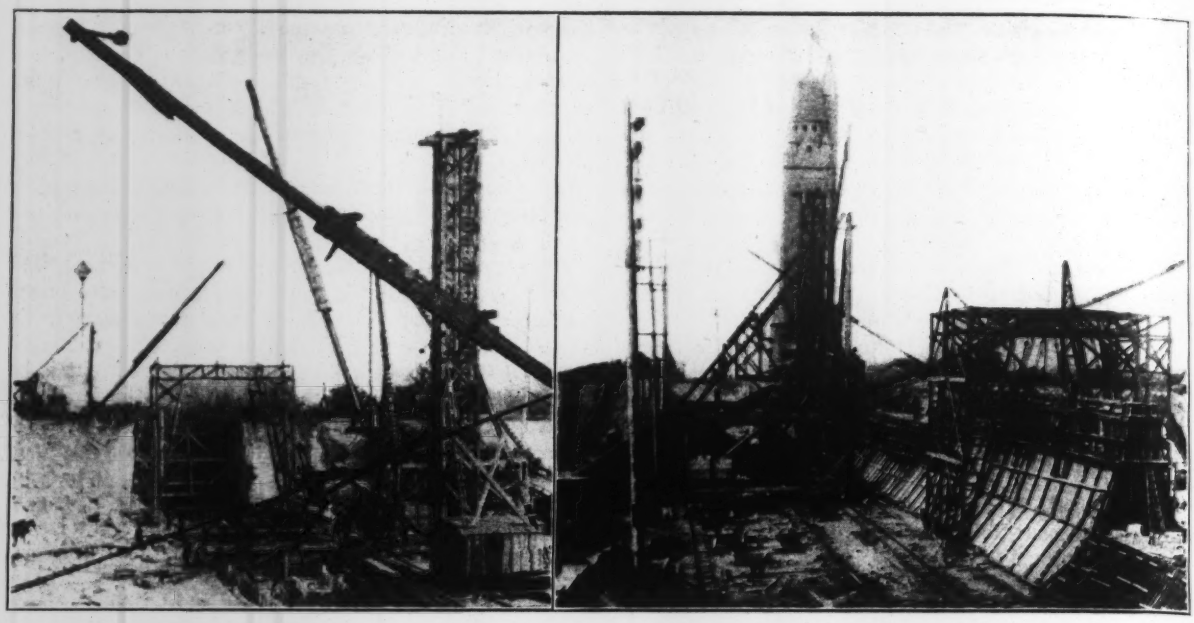


FIG. 1. CONSTRUCTION PLANT ON THE REPAIRS OF THE COMPTON HILL RESERVOIR AT ST. LOUIS

Reconstruction of a Reservoir at St. Louis, Missouri

SYNOPSIS—To check leakage from the earth-embankment reservoir at Compton Hill a new lining is being built and steel sheeting driven through the bank to rock. A new crosswall is also being built. In addition a wall will be built above the present top in order to allow of raising the water level. Concrete piles are used under the walls.

The Compton Hill reservoir at St. Louis has had considerable leakage. Within the past few years this has amounted to nearly 1,000,000 gal. daily. The loss of so much water after the expense incurred in pumping and purifying it has warranted the cost of extensive repairs to stop the leakage. No damage has been done by the escaping water, as it has been carried off by the sewers.

The reservoir is about 850x500 ft. in plan and 20 ft. deep, with a capacity of 65,000,000 gal. It is formed partly by excavation, but mainly by an embankment of stiff red clay, 20 ft. wide on top, with inner and outer slopes of 1½:1 and 2:1 respectively. A puddle wall in the bank was connected with the puddle floor. The slopes were paved with stone blocks on a layer of macadam, and the leakage was largely through this paving. A masonry crosswall divided the reservoir into two basins. This reservoir was completed in 1870.

The work now undertaken to stop the leakage includes the following: The lining of the old floor and slopes with reinforced concrete; the driving of a continuous line of steel sheeting from the top of the bank to rock; the construction of a concrete wall around the top on concrete piles and the steel sheeting; the removal of the old division wall and construction of a new concrete wall, having concrete piles and a cutoff wall extending to rock; the reconstruction of the gate chambers and erection of a new gatehouse.

In this new work the sides and the division wall will be carried up so that the water level can be raised about 10 ft., increasing the storage capacity by about 29,000,000 gal. The work is under the direction of Edward E. Wall, Water Commissioner; G. G. Black is engineer in charge of the Water Division, and F. R. Wiederholdt is Resident Engineer. The contractor is the Hiram Lloyd Construction Co., of St. Louis. The cost of the work will be about $280,000.

Construction of New Division Wall

The reservoir cannot be kept out of service for any great length of time, and the plan adopted was to rebuild the division wall at once, so that water can be stored in one basin while work is in progress on the other. The contract provided, therefore, that between Sept. 15 and Dec. 15 the contractor must reconstruct this wall and the gate chambers at each end, connect the slope and bottom paving of one basin with the wall and chambers, and make this basin sufficiently water-tight for immediate use.

The division wall, Fig. 5, is of reinforced concrete, 37 ft. high, 30 ft. wide on the base and 3 ft. at the top (4 ft. over coping). The batter decreases from 9⅜ in. in 12 in. at the lower portion to ½ in. in 12 in. at the top. Beneath the middle of the base is a 36-in. cutoff wall extending to rock at a depth of about 15 ft. This cutoff wall also extends under the gate chambers. Under each side of its base are two rows of concrete piles driven to rock. The rows are 4 ft. c. to c. and the piles in each row 3 ft. c. to c., not staggered. The construction of the foundation of the wall is shown in Fig. 3.

There are four expansion joints extending the full depth of the wall. These are spaced 129 ft. apart, the

two end joints being at the connection with the walls of the gate chambers. They are of the tongue-and-groove type, as shown, and the filling is built up of alternate layers of felt and asphalt to a thickness of ¾ in. The ends of the walls at these joints have extra vertical reinforcing bars, also horizontal bars bent to fit the tongue and groove.

The concrete is a 1:2½:5 mix, made with crushed limestone or Meramec River gravel of ¼- to 2-in. size, and sand passing a ¼-in. screen. This proportion gives 1 sack of cement to 6 cu.ft. of concrete. No crusher-run stone is permitted. The steel reinforcement consists of round rods. All wires or metal ties for securing the forms must be cut off at least ½ in. from the face of the wall and the holes filled with 1:2 cement mortar. A certain amount of the old stone blocks is allowed to be placed in the new concrete as pudding stone or plums. The remainder is crushed by a crusher erected on the floor of the reservoir for use as concrete aggregate, the contractor disposing of the screenings for street or other work. The old wall contained about 6,000 yd. of masonry, and the new one will have about 10,000 yd. of concrete.

Reinforcing the Sides of the Reservoir

The interior slopes of 1½ on 1 have a paving of 16-in. stone blocks laid on 6 in. of macadam and grouted with cement. This paving will be thoroughly cleaned and covered with 3 in. of concrete, upon which will be a waterproofing course composed of six layers of asphalt and five of felt. Upon this will be a 3-in. concrete covering, reinforced with wire netting and laid in slabs 8 ft. wide, with a horizontal joint along the middle of the slope. In order to thoroughly bond the first layer of concrete with the stone paving, some of the paving blocks will be removed (one for each 64 sq.ft. of surface), the concrete being filled into the opening to form a key, or anchor.

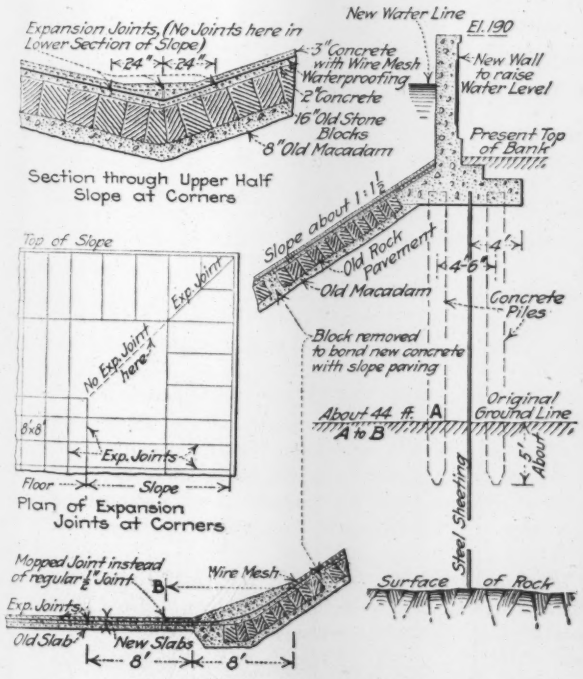


FIG. 2. SLOPE LINING AND REINFORCEMENT OF COMPTON HILL RESERVOIR

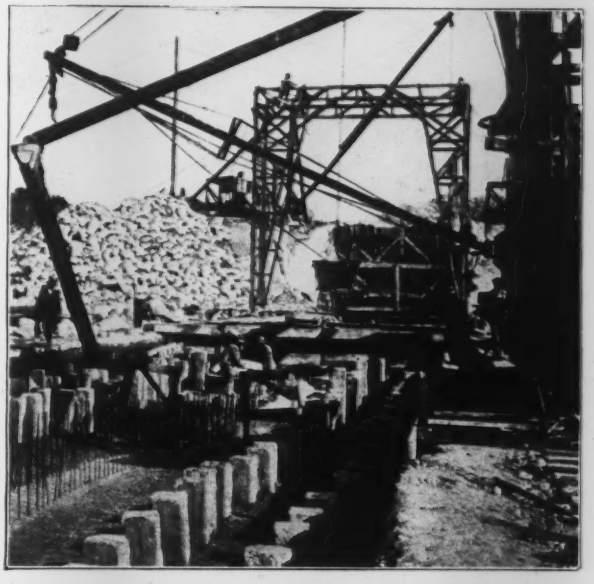


FIG. 3. CONCRETE PILES AND STEEL REINFORCEMENT FOR THE BASE OF DIVISION WALL

The four rows of concrete piles are under the footing, and the reinforcing rods project from the top of the cutoff wall which is carried down to rock. The rock pile at the left is for plums in the concrete. At the end of the wall the men are erecting the traveler for the forms. At the right is the traveling concrete plant, with boom to support the steel chutes

Fig. 2 shows a cross-section of the work and also the arrangement of expansion joints in the floor and slopes.

To prevent the escape of any water through the bank, a row of steel sheetpiling will be driven to rock, as shown. Borings were made at intervals of about 25 ft., showing minimum and maximum depths of 36 and 53 ft., the depth to rock being mainly about 40 to 45 ft. The sheeting is of the Lackawanna arch-web type, and will be driven by a steam hammer. To facilitate this work, the engineers at the site measured the piles and marked each with its length, so that they could be distributed around the reservoir according to the depths shown on the profile.

To enable the depth of water to be increased, a reinforced-concrete wall will be built around the inner edge of the bank, as shown in Figs. 2 and 4. This will be 18 in. thick, with a total height of 13 ft. (or 8 ft. above the footing). The top will be 4 ft. above the new water level. This wall will have a broad footing connected to the new slope paving and will be supported on two rows of concrete piles and the line of steel sheeting. The piles will be 3 ft. c. to c. in each row, staggered, and will be 24 ft. long, giving a penetration of about 5 ft. into the natural ground below the bank.

For this wall the concrete will be made with broken stone of ⅛- to 1-in. size. The mix will be about 1:2:4, giving 1 sack of cement to 4½ cu.ft. of concrete, while to increase the density hydrated lime will be added in the proportion of 10 lb. of lime for each sack of cement. The exterior of the wall will have a simple architectural treatment, as shown. The panels will be bush-hammered, while the remaining part of the exposed outer surface will be rubbed down with carborundum blocks and water.

In building this water-tight wall, 15-in. strips of No. 22 black sheet iron will be embedded in the concrete at all construction joints, to form effective water stops.

The original paving of the floor was of concrete slabs. These will be removed only where required to make room for the new division wall (Fig. 5). After the floor is cleaned of dirt and loose material it will be covered with two 3-in. courses of concrete in blocks or slabs about 8 ft. square, the joints of the upper course breaking joint with those of the lower. This is shown in Fig. 2. Between the two courses will be a waterproofing course similar to that on the slopes, except that pitch will be used instead of asphalt.

The gatehouse will be a concrete building 48x25 ft., over the south gate chamber. Here there will be orna-

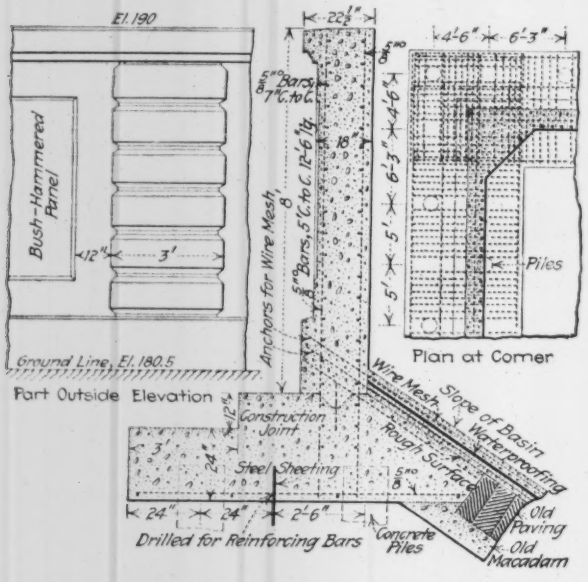


FIG. 4. NEW RETAINING WALL ON TOP OF RESERVOIR
This is bonded to the slope lining and the new water level will be 4 ft. below top of wall

mental stairways, a fountain and other features of architectural treatment. Much of this work will be of cast concrete blocks, the concrete being made with stone of ⅛- to 1-in. size (but without sand) in proportions of 1 : 3½ to 1 : 5. It is reinforced to give sufficient strength for handling and to prevent cracking. The building and decorative features were designed by Roth & Study, architects, of St. Louis.

Reinforced-Concrete Piles Used

The specifications permitted the use of concrete piles either straight or tapered and of any form of cross-section, provided that the surface area should be not less than that of a cylindrical pile 15 in. diameter. The contractor preferred to use straight piles, 12½ in. square, with 1-in. chamfer on the corners. The point tapers in 12 in. to 8x8 in. at the end.

The concrete is a 1 : 4½ mix, made with gravel of ¼- to 1-in. size, except that at the ends it is 1 : 3½. The reinforcement consists of six ⅝-in. bars, having the ends bent inward. These are bound by hoops ¼x1 in. about 4 ft. apart, and wrapped spirally with No. 10 wire having a pitch of 4 in., reduced to 1 in. for 18 in. at each end. The bars are wired to the hoops and spiral. They are 1 ft. shorter than the pile, and no reinforcement must come within 6 in. of the head of the pile. These piles will be driven by steam hammers, cushion caps being placed on the heads of the piles.

The concrete piles are made in a yard at the foot of the bank of the reservoir. At one end is a ½-yd. concrete mixer, from which the concrete is delivered to the pile forms by wheelbarrows. Then comes a platform on which the piles are cast and which is long enough for seven rows of 23-ft. piles, with ten in each row. At the other end of the yard is the storage space, where the piles are stacked horizontally while curing.

The platform is heavily built and carefully leveled, so that the piles can be cast directly upon it, and only side forms are required. These are of wood and are used several times. An iron cap, however, is used for the point. The bending of the bars is done by hand. For placing the hoops and wire wrapping, the six bars are fitted to two disks on a long pipe supported on horses and turned by a crank handle at one end. This plant can make 40 piles per day.

The piles remain in the forms for 24 hr. (48 hr. was allowed at first) and are then picked up and removed to the storage stacks by a traveling gantry which spans the yard. This gantry consists of an I-beam of 32-ft. span supported at the ends on timber A-frames 16 ft. high, each mounted on two wheels. On the I-beam runs a trolley hoist carrying a swing beam having chain slings. This gantry is moved by hand. The piles are held at least 30 days for curing and are sprinkled twice daily.

Construction Plant and Methods

The first part of the work, as noted already, was the reconstruction of the division wall and the gate chambers at its ends. This work had to be done rapidly, as explained.

The old stone masonry was drilled by hand, 6-ft. holes being put down by "jumping" long drill rods. Light charges were fired at the end of each shift. The masonry thus thrown down upon the floor was removed in various ways—by a small flat-car on an industrial railway, by stone boats with teams, by chains handled by teams or derricks, and especially by the use of two light steam shovels. These shovels also rooted up the old concrete footing.

Part of the stone was piled for use as plums in the new concrete wall, and part of it was hauled by stone-boats and dump wagons to a stockpile adjacent to a crusher and screening plant erected on the floor of the west basin, in connection with the concreting plant. The earth and rubbish were hauled away in dump carts and used for filling vacant lots owned by the contractor within a few blocks of the reservoir. Screenings from the stone crusher were removed in the same way and used for filling or sold for street-repair work.

For bringing in supplies and hauling away material, two inclined roadways of 12% grade, supported on timber trestling, were built from oposite sides of the bank down to the floor of the reservoir. Loaded wagons were assisted up the inclines by snatch teams or by a cable from a hoisting engine. Concrete material was dumped through openings in the inclined roadways, falling into bins beneath.

For removing the old wall and handling the stone plums of the new wall there are two stiff-leg derricks, mounted on rectangular towers and having 40-ft. masts and 85-ft. booms. They travel on a wide-gage track laid parallel with the wall and are propelled by power. Between the derricks and upon the same track is the traveling

concreting plant, on a platform 14x24 ft. This carries a 3½-yd. mixer and 70-ft. elevator tower, with bucket supplying the gravity chutes. It travels the full length of the wall in about three hours. Wood forms are used, built in sections and handled by a traveler spanning the wall.

Two general views of the work are shown in Fig. 1. The view at the left shows the concreting plant and tower with one of the traveling derricks beyond it. The derrick at the left, on top of the bank, is erecting the traveler for the forms. In the other view there is one of the inclined roadways at the left, and in front of the water

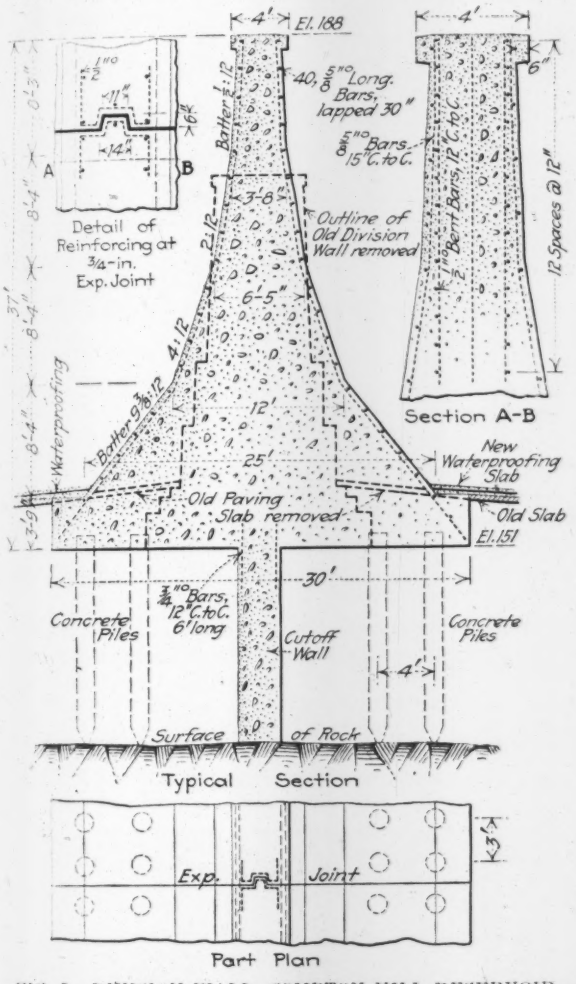


FIG. 5. DIVISION WALL, COMPTON HILL RESERVOIR

tower is the concreting tower and a derrick. At the right is the wall under construction.

The work is carried on by night and day, in two 10-hr. shifts, except that the carpenters work 8-hr. shifts. For the night work there are eight 500-watt tungsten lamps on a wire stretched over the reservoir. These give an excellent light, but during the blasting the lamps were frequently shot out.

The Bergen Turnpike, said to be the last toll road in New Jersey, has been purchased by the Bergen County Board of Freeholders. The turnpike has been owned by the Public Service Corporation, which operates a street railway on the turnpike. It extends from Hackensack to the Hudson County line. Tolls have been collected at four toll gates since 1802, and ever since then Bergen County farmers have had to use this thoroughfare across the Jersey meadows to reach the New York City markets.

A Survey Yarn from Kansas

By A. G. Barnett, Jr.*

Paul Bunyan, who worked as County Surveyor out in Kansas, had some reputation in his profession. The following is an account of a job he did for Silas Emery. Silas himself told the story to a party of Rock Island engineers who had taken refuge in his toolshed from one of the Sunflower State's justly famous summer showers.

"I hired Paul," said Silas, "to run out my north line because my neighbor was aimin' to string a fence on what I knowed was my land. They had been a stone sot twenty rod notheast o' my cow barn when the widder Smith owned the layout, but seemed as if I couldn't rightly locate the durn thing. But Paul, he had the guvment notes fer the whole county and the one west, so I knowed he could fix me up proper.

"Well, out him and his long-laigged boys come one mornin' at sun up and set out to find a monnyment to start out from, but they didn't find none till they come to the second range line east; but that there was a buffalo horn set seven inches down in gravel at the aidge of a crick, as the notes called for, so Paul he felt safe to start and they lit out. They'd chain out eighty rod after the compass was set level and the proper deeclination set off, and then Paul would pull up his instument and go whar the boys had got to and start em off agin. And then this-away, bein' right pert steppers, they seevayed them seven miles in two hours, and come to where my corner was supposed to be at. I recollect Paul he was lookin' mighty cocky when he come up to whar the last pin was stickin' in the ground.

"'Thar she be,' he sings out, 'jest six inches underground, and if you'll shove down on that there pin you can find her yourself.' Wa'll, I goes over and shoves her in clean up to the red flannel but nary stone did I tetch ner feel.

"Now Paul havin' the name he had for doing tiptop work I felt right disappointed thinkin' of him amissin' that stone, and I reckon I showed my feelin's some too. Paul, he wasn't lookin' so cocky no more neither. Never did I see a feller more put out. He reads all his guvment notes over time and agin, and him and the boys they puts down a whole raft of figgers and takes turns a addin' them up.

"Then Paul gits up and takes their sightin' pole and rams her down where the pin was settin'. Full two foot he druv that there pole down 'fore he give it up as a bad job, and set down and went to pawin' over that old yaller note book agin. 'Fore he set down, though, he allowed as how he'd give up and take to ranchin'.

"Finally I heered him snickerin' and I looked over to whar he was, and thar he set grinnin' fit to kill. 'Come here, Si,' sez he, 'and read the discripshun of this here monnyment.' Seems he had overlooked readin' that there discripshun all this time cause of it bein' over on the right-hand page with figgerin' all 'round and runnin' into it. But thar it set, writ plain enough for anybody once you noticed it. 'For the notheast corner of section 14, havin' run out of buffalo horns, I set an old grindstone purloined from the widder Smith's shed, six inches below the surface of the ground.'

"Yep, the pole Paul hed shoved down two foot was stickin' plumb through that there corner."

*Madison, Wis.

Continuous Wire Winding for Wood-Stave Pipe

A new type of wood-stave pipe has recently been developed in California and has been used in building two conduits of considerable length. Engineers everywhere are familiar with the continuous wood-stave pipe in which the staves are secured by round steel hoops meeting at a joint piece and secured by nuts. Smaller sizes of wood pipe have long been on the market in which the exterior of the pipe is wrapped with a spiral wire winding, the pipe being made up in convenient lengths with the wire winding secured at the end. In laying pipe of this latter class, joints have to be made of course between the successive lengths of pipe.

The new type of pipe is a continuous stave pipe wrapped with a continuous helical winding of wire. The wire is wound on the pipe after it is laid in place by a machine, illustrated in the accompanying cut, which winds the wire with a uniform tension and uniform pitch, both the tension and the pitch being adjustable according to the size of the pipe and the water pressure which it is to sustain.

The machine is a simple and rugged affair, and has a gear wheel which encircles the pipe and is driven through speed-reduction gearing by a small compressed-air motor. As this gear wheel is rotated around the pipe it is at the same time given a longitudinal motion along it. This rotating gear wheel carries rollers between which passes the wire to be wound on the pipe, and these rollers are adjustable to give the wire the desired tension. The wire is unwound from a reel that encircles the pipe ahead of the machine.

When a new reel of wire has to be put on, the ends of the wires are welded together by a miniature electric welder furnished with the apparatus. After the electric welding, the joint is regalvanized. The necessity for the electric-welded joint arises from the fact that in order to pass through the machine with even tension the wire must be of uniform diameter and flexibility, a result which could not be obtained with the telegraph lineman's splice.

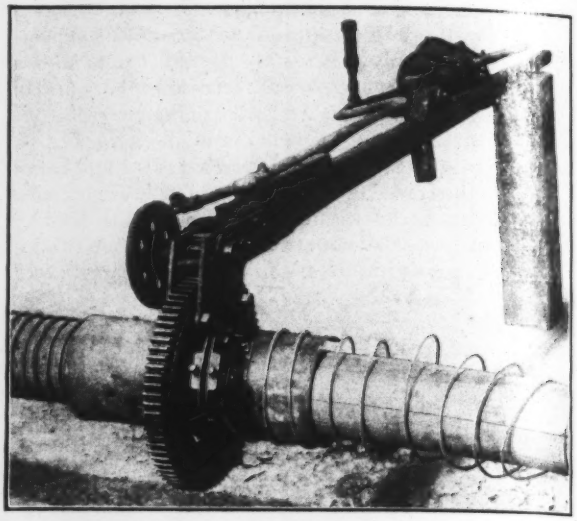


FIG. 1. MACHINE FOR APPLYING A CONTINUOUS SPIRAL WIRE WINDING TO WOOD-STAVE PIPE

After the wire is wound on the pipe and before it is lowered into the trench, the entire pipe with the wire winding is given a heavy coating of asphalt. Fig. 3 illustrates the method of applying the asphalt. A sleeve slightly larger than the pipe has elastic and flexible ends made of fabric which fits snugly over the pipe. By means of a funnel on top, this sleeve may be filled with hot asphalt. It is then drawn slowly along the pipe. It is claimed that by using galvanized wire and heavily coating the pipe with asphalt a long life for the pipe is assured.

The first pipe of this type was laid about four years ago by the Standard Oil Co., of California, near Bakersfield, to furnish a water-supply to a refinery. The pipe is 18 in. in diameter, about 2,400 ft. in length, and carries a maximum head of 60 ft. Recently a longer pipe has been laid for the California Pine Box and Lumber Co., at Delleker, Calif. This line is 6,500 ft. long, of 10-in. diameter, and is under a maximum head of 200

FIG. 2. LAYING A CONTINUOUS WIRE-WOUND WOOD-STAVE PIPE LINE

FIG. 3. APPLYING ASPHALTUM AFTER LAYING

Flexible hose conveys compressed air from a portable compressing outfit to the motor which drives the wire-winding machine. The portable electric welder for joining the lengths of wire is seen at the right of the left-hand view

ft. About 180,000 ft. of No. 4 galvanized wire was used on this line, and 120 welds were made. The spacing of the wire was from $1\frac{1}{16}$ to $2\frac{7}{16}$ in., according to the head on the pipe. The line was laid through very rough country, and some curves as sharp as 30 deg. were made. The pipe was laid at the rate of about 450 ft. per day.

An important advantage claimed for this pipe is its low cost, especially for pipe lines of small diameter. In comparison with wood-stave pipe made up in lengths, the entire expense of the joints is saved; and further, the staves for the pipe can be shipped at much less cost than the made-up lengths of pipe. The pipe can be bent to sharp curves as it is built up, and a great deal of expense in carrying a pipe line through rough country is saved by adapting the pipe line to the contour of the ground.

Ordinary wire of 60,000-lb. tensile strength is used, and wire of various diameters can be used according to the size of the pipe and the pressure it is to carry.

This new method of constructing wood-stave pipe is controlled by the Continuous Wire Wound Pipe Co., Room 1216, Flood Building, San Francisco, Calif.

Engineering-Education Faults

By W. M. Wilson*

Engineers feel that they are not receiving the recognition they deserve. Engineering as a profession apparently does not stand as high in the eyes of the public as do the law and medical professions. Public affairs are in the hands of lawyers, doctors and business men. Commissions, even when called upon to consider questions involving engineering problems, are seldom controlled by engineers.

Although engineers may feel that they are not getting a square deal, as evidenced by the discussions in the engineering periodicals, it is well to remember that men are appointed to commissions, not because they are doctors, lawyers, business men or engineers, but because they have seen the need of society for this thing for which the commission stands, because they are men of ability and reputation and are willing to sacrifice their time and money for the public welfare, qualities which are essential in one who would serve on a public commission.

Are Engineers at Fault?

In view of this fact, does it not seem that the fault may be with the engineer rather than with the public or the ones in power? Since engineering education, as distinguished from other kinds of education, has been in vogue about half a century, if engineers are failing to meet the standards of a learned profession, may not the fault be in their professional training?

Engineering has been defined as the utilization of the resources of nature for the benefit of mankind. In considering the education of an engineer it is this comprehensive view of his work which the writer has in mind rather than the more popular view that an engineer is a person who surveys a railroad, designs a generator, runs an engine or does any other one thing which requires a highly specialized technical training. It is the failure to understand the function of an engineer that is responsible for so many poorly planned courses of study in our schools and that is also responsible for men being classified as poorly paid engineers who are really well-paid mechanics.

University courses of study have changed rapidly. During the early part of the last century they included only the study of pure science, philosophy and literature. About the middle of the century a few schools introduced courses in applied sciences. These met with but little encouragement at first, but finally grew in popularity, until near the close of the century a huge wave of popular engineering education flooded the country. Though this, on the whole, was a good thing, it carried with it some undesirable features. Chief among these was an irresistible demand for what were spoken of with pride as practical courses. It seemed to be the prevailing opinion that in some mysterious manner a student could attain a greater proficiency in certain highly specialized mechanical processes after a few hours' practice each week for a few months than a mechanic could acquire working day after day for years.

Although trade-school training is recognized as valuable to a man who expects to spend his life as a mechanic, the better engineering schools soon realized that such work could not take the place of scientific training for the man who expected to be, not a technical expert, but an engineer in the broader sense of the word. Manual training has therefore lost its standing as a part of a university course of study, and though shop work is still given in most first-class engineering schools, it is used more to illustrate the principles of scientific shop management than to train expert mechanics.

Over-specialization a Menace

Although the danger from over-emphasis of manual training has been largely done away with, the engineering schools of today are facing in over-specialization an even more serious menace. All engineering work was originally classed as either military or civil engineering. Civil engineering was later divided into four major divisions, known as civil, mechanical, electrical and mining engineering. At the present time some of our schools, at least, are apparently vying with one another in their endeavor to subdivide each of these major divisions into the largest number of attractively named subdivisions. Some of the schools frankly admit that this is done for advertising purposes. Manufacturers, however, recognize that any advertising scheme that injures the product is poor business policy.

Schools which recognized the folly of trying to train expert mechanics are, nevertheless, now trying to do for office work what a few years ago they tried to do for shop work. A man who does the technical work in a specialized line of engineering uses certain scientific facts over and over, day after day, and becomes expert at his particular process just as a mechanic does. In a sense he is a mechanic. Although a higher order of mentality is required, it is a difference in degree rather than in kind. Given sufficient training, it is something that almost any one can do. It would seem, therefore, as illogical for universities to train expert draftsmen and calculators as it is admitted to be for them to train expert mechanics.

It is true that special training in college will help a draftsman or a calculator just as a trade school will help

*Assistant Professor of Structural Engineering, University of Illinois, Urbana, Ill.

a mechanic. But although special training is helpful, a greater benefit can be obtained by devoting to other things the time required for training in a specialized line.

All the sciences have developed rapidly during the evolution in education. The pure sciences on which our engineering work is based have increased in scope many times in the last half century. The principles of economics which play such an important part in engineering in its broader sense are just beginning to be understood. Practically all successful engineers in addressing young men emphasize the value of expertness in self-expression, but practically none dwell upon the necessity for technical training. With all of the wealth of knowledge useful in all human activities that is available it would seem to be the height of folly to spend any part of a student's time on a special line of work. The routine duties of specialized industries can best be learned in commercial life. But if science and literature are neglected in college they are not likely to be courted in after life in a busy world.

How to Produce Broad-Minded Men

If after half a century of engineering education the most severe and insistent criticism of our engineers is narrowness, then the training of engineers should be changed so as to produce broader-minded men. If our engineers can build good railroads, but fall short of the highest success because they fail to see the relation between a railroad and the development of a new territory, then let us teach less of bridge design and railroad surveying and more of economics. If our engineers can design and construct an efficient sewer system, but cannot induce a community to install it, then let us teach less of sewer systems and more of sociology. If our engineers are intensely interested in equipment for factories, but are indifferent to the happiness of their families and the health of their employees, then let us teach less of machine design and more literature, philosophy and sociology. A man cannot lightly claim membership in a learned profession if he cannot see beyond the technique of his work.

The argument that a specialized course fits one for his lifework does not hold. In most cases boys do not know what line of work they want to follow. The selection of a university course is often based upon a mere whim, and seldom is the choice made on a basis of solid facts and sound reasoning. A special course is as likely to cause a student to persist in a line of work for which he is not fitted as it is to fit him specially for his career.

Some men may be so fortunate as to be able to pick their job upon graduation, but more often the line of work one enters is determined by the kind of job he can get. Nearly all men have to shift a few times before they find the line of work for which they are best suited. There is a striking illustration of this fact at the University of Illinois. Of six men in the Civil Engineering Department having professorial rank, only two have taken a course in civil engineering.

It is evident that all advantage to be gained by specialization in an undergraduate course is lost in this adjustment. Moreover, observations show that where engineering graduates and graduates of science or literary courses work together, any advantage which the former may have immediately upon graduation is soon lost.

Engineering covers a broad field and requires not a special knowledge, but a broad view and sound judgment. It is true that many parts of an engineering project require for their execution men having highly specialized technical training. But all of these processes are based on much the same fundamental scientific principles. Because of their universal applicability, these principles should be known by all engineers and therefore may properly be a part of a university course. Each of the highly specialized processes, on the other hand, is used by comparatively few, and can best be learned by daily repetition in commercial work. Training in these processes should therefore form no part of a university course. An engineer in the broader sense is a man who can conceive a project, have it financed and then organize an army of workmen to carry it out. One of these three functions is as important as another. The graduate who will develop into this type of man is what our engineering schools should produce. He is more likely to be produced by a broad training in science, art and literature than by a narrow specialized training in technical subjects.

A school should be interested in the career of its alumni fifteen or twenty years after graduation rather than in a meteoric success during the first year or two. This fact is becoming more and more realized; eventually it will predominate. When that time comes the courses of study in the universities, which originally included only pure science, literature and philosophy, which were later flooded with manual training, and which now are made up largely of highly specialized subjects, will then return to almost their original state. They will, however, contain a more constructive knowledge of literature and a greater wealth of science. Moreover, instead of the application of the sciences to the problems of engineering, the principles governing the application of the sciences will be emphasized.

⁂

New York State Barge Canal Prospects—The eastern half of the Erie Canal and the Champlain Canal have each a single unfinished and unawarded contract which has been the chief obstacle to the entire completion of its respective section. By letting these contracts, together with one or two bridge contracts, and by pushing work on them and on the few other contracts which are under award but not quite completed, it is expected that one season's time will be all that is needed to finish the Champlain Canal and also a channel from the Hudson to Lake Ontario by way of the Erie and Oswego branches. The Erie Canal west of the Oswego junction contains several uncompleted portions. Here legal complications are largely responsible for the unfinished condition. There are numerous railroad crossings and these have proved to be very troublesome from the standpoint of the state, both because of delays in coming to agreements with the railroad companies and on account of the slowness in performing the work in such manner as not to interrupt traffic. Because of the amount of work still to be done and the number of crosings still to be made, it is anticipated that two seasons will be required to complete the western half of the Erie Canal. The State Engineer intends to do his utmost to have all uncompleted work under contract at the earliest possible moment, so that the state may no longer than necessary be denied the benefits of the completed waterway and meantime may utilize its finished parts. Thus he will justify his prediction that the Champlain Canal can be completed in one year, as can also the canal between Waterford and Oswego and the branch into Cayuga and Seneca lakes, and that the balance of the canal through to Buffalo can be finished in two years. To do this, however, it will be necessary for the legislature at the beginning of its session and as one of its first acts to make provision for the immediate issuing of the bonds authorized by the vote of the people at the last election, in amount $27,000,000.—From "Barge Canal Bulletin," November, 1915.

Surface-Water Investigations; U. S. Geological Survey

By John C. Hoyt*

The determination of the quantity of water in the surface streams of the country forms the principal work of the surface-water division, water resources branch, United States Geological Survey. For carrying on this work, in addition to the central office at Washington, 15 districts have been established on the mainland of the United States and one for the Hawaiian Islands. Each district has a local office, as noted in the list, with a district engineer, an office engineer, an office clerk and one or more engineering assistants. The total number of men regularly engaged in the work averages about 80.

Division Offices

The districts and their respective offices are as follows: New England, Custom House Building, Boston, Mass.; New York, 19 Federal Building, Albany, N. Y.; Northern Atlantic, United States Geological Survey, Washington, D. C.; Southern Atlantic and eastern Gulf, 305 Federal Building, Atlanta, Ga.; Ohio River, United States Geological Survey, Washington, D. C.; Upper Mississippi River, care of Railroad Commission, Capitol Building; Madison, Wis. (Sub-office: Old Capitol Building, St. Paul, Minn.); Missouri River, Montana National Bank Building, Helena, Mont.; Rocky Mountain, New Federal Building, Denver, Colo.; Great Basin, 421 Federal Building, Salt Lake City, Utah; Washington, 406 Federal Building, Tacoma, Wash.; Oregon, 416 Couch Building, Portland, Ore.; California, 328 Custom House, San Francisco, Calif.; (Sub-office: 619 Federal Building, Los Angeles, Calif.); Arizona, 417 Fleming Building, Phoenix, Ariz.; Texas, Old Post Office Building, Austin, Tex.; Hawaii, Kapiolani Building, Honolulu, T. H.

At the end of the fiscal year, June 30, 1915, there were 1,394 stream-measurement stations being maintained. During the year 282 new stations were established, and 260 stations were discontinued. The observations at these stations are used in computing the daily flow of the streams. For obtaining gage heights 375 of the stations are equipped with water-stage registers which give a continuous record of the fluctuations. The remainder are equipped with staff or chain gages from which daily fluctuations are determined by one or two readings made each day by a local observer. The automatic gages are also frequently inspected by local observers. The type and number of gages are as follows: Stevens graph, 172; Friez graph, 81; Gurley graph, 10; Gurley printing, 28; miscellaneous, 84.

During the last fiscal year 7,241 measurements of discharge were made at the regular gaging stations and 983 at miscellaneous points, or an average of 6 discharge measurements for each gaging station.

In carrying on the work during the fiscal year nearly $220,000 was expended from the district offices, as follows: Federal appropriation for gaging streams, $77,751; coöperation from Federal bureaus, $31,508; coöperation from state organizations, $94,193; miscellaneous coöperation, $16,169. A detailed cost-keeping system is maintained for all expenditures. The basis for this system is a charge sheet accompanying each voucher, on which the amount indicated on the face of the voucher is divided among the various cost-keeping items under the following general headings: operation and maintenance; construction; office work; top cost; nonexpendable property. The first two items are subdivided under services, labor, transportation, subsistence and materials.

From the charge sheets, expenditures on account of the various projects are posted on the cost sheet for that project. The following data in regard to costs, as shown from the annual cost-keeping summary for last year, are of special interest: Average cost of maintenance per station for a full year, $188.06; average cost per month's records, $15.69; operation and maintenance, 49.4%; construction, 12.1; office work, 19.1; top cost, 16.6; nonexpendable property, 2.8.

The above costs include only the expenditures in the district offices and not those in the Washington office, where general administration is carried on and the data are finally checked and prepared for publication.

In the execution of the work all processes have been standardized as far as possible. Each district office uses the same filing systems and in general follows the same methods. Standard equipment has been adopted and is furnished the various district offices from stock maintained in the Washington office. By this means a large saving is made as the cost of special material made locally in small quantities is usually excessive. The standards are maintained by thorough inspection and by annual conferences of the district engineers.

Publications and Coöperation

The results obtained are published annually in a series of water-supply papers, under the general title of "Surface Water-Supply of the United States." For convenience in the publication and use of the records, the United States has been divided into twelve sections, as follows, and a separate report is published for each: (1) North Atlantic coast (St. John River to York River); (2) South Atlantic coast and eastern Gulf of Mexico (James River to the Mississippi); (3) Ohio River; (4) St. Lawrence River and Great Lakes; (5) Hudson Bay and upper Mississippi River; (6) Missouri River; (7) Lower Mississippi River; (8) Western Gulf of Mexico; (9) Colorado River; (10) Great Basin; (11) Pacific Coast in California; (12) Northern Pacific drainage basins. Water-Supply Papers 351 to 362, which contain the data for 1913, comprise over 3,300 pages, of which about 80% is tabular matter.

The district offices serve not only as headquarters for carrying on the work, but also for the general use of the public. Complete files of data and publications are kept and are much used by engineers and others who are interested in the water resources of the area covered by the district.

As indicated by the large amount of coöperative funds received from State organizations, State interest in the work is large. During the last year there was coöperation in Arizona, California, Colorado, Connecticut, Idaho, Illinois, Kentucky, Iowa, Maine, Massachusetts, Minnesota, Montana, Nevada, New Mexico, North Dakota, Oregon, Utah, Vermont, Washington, West Virginia, Wisconsin, Wyoming and Territory of Hawaii.

*Hydraulic Engineer, in charge of Surface-Water Division, United State Geological Survey, Washington, D. C.

Massachusetts Experimental Concrete Pavement

In response to an inquiry, W. R. Farrington, Division Engineer, Massachusetts Highway Commission, Middleboro, Mass., has furnished the following information regarding an experimental concrete road recently constructed in the town of Randolph, about 12 mi. from Boston. This section of road is 9,563 ft. long, and the concrete surface is 18 ft. wide (with rounded edges), 8¼ in. thick in the center and 6 in. on the sides. The surface has a crown of ¼ in. to the foot. The subgrade (transversely) is level.

The concrete was mixed in the ordinary proportions of 1:1½:3 with crushed stone, but 8% of hydrated lime was added to and mixed with the cement before placing in the mixer. The lime was used to form a denser mixture, with the expectation that such a mixture would be more impervious to water than the ordinary mixture and thus less subject to frost action. It is also claimed that the lime aids in retaining the moisture and tends to prevent the outside of the mass from setting more quickly than the inside. As far as the handling is concerned, the only difference noted was that the addition of the lime somewhat retarded the setting of the concrete.

The concrete was mixed in a self-propelled batch mixer equipped with boom and bucket, so that concrete could be deposited in place without rehandling or the use of a chute. Steel forms set to line and grade were used, and the edges of the concrete were rounded with a tool to a 3-in. radius after the concrete had partly set. This has been found more satisfactory than beveling the edges of concrete by the use of a strip fastened to the forms.

The concrete was leveled with shovels, slightly tamped, and struck off with a sheet templet made of angle iron, the ends of templets resting on the forms when in use. After the use of the templet the surface was floated with a long-handled float—the float being about 12x24 in. and the handle set at an angle of about 45°—and finished with an ordinary small wooden hand float. Where armor plates were used at the joints the surface was floated over the joints. On the remainder of the road the surface at the joints was finished with a special split-float.

The surface was not broomed, although some of the concrete surfaces previously constructed by the Massachusetts Highway Commission have been broomed enough to roughen the surface slightly. Brooming, although affording a somewhat better footing for horses, has caused considerable complaint from users of motor vehicles.

The concrete while setting was protected first by canvas covering and later with hay, which was kept wet for about two weeks. On concrete road work in this state both sand and hay have been used for covering. The sand generally has been found preferable if obtainable at a reasonable cost, although the hay ordinarily gives satisfactory results.

On most of the road the transverse expansion or contraction joints were spaced 30 ft. apart, but on one section a 100-ft. slab was tried, it being thought that possibly with a mixture containing lime the joints could be spaced farther apart. Genasco filler and three-ply asphalt roofing paper were used in the joints—the filler (⅜ or ½ in. thick) being used at about every third joint and the paper in the remainder. On a section about 700 ft. long, armor plates were used at the joints.

Several different brands of cement were used and the aggregate was broken stone passing a 1¼-in. screen but retained on a ½-in. screen. The sand was rather fine, but sharp and within the standard specifications for such work.

In making the concrete the batch was turned from ¾ to 1½ min., the mixer making from 7 to 14 revolutions, depending on the conditions.

The cost of the concrete surface, including all materials, was $1.29 per sq.yd., or $6.46 per cu.yd.

The Central Railway Station at Tokyo, Japan

By Charles Potter*

In the City of Tokyo, now said to be the third largest city in the world, there has recently been completed a railway station of a size and elaboration favorably comparing with the recent large stations of the United States. The Japanese railroads, all under governmental ownership, center in the capital. There have been heretofore three separate stations for each of the three main lines converging at the city. In the interest of efficiency and convenience it was decided in 1908 to centralize the terminals and to bring all of the tracks into one union station. The

FIG. 1. TRACKS AND TRAINSHEDS UNDER CONSTRUCTION AT THE NEW STATION IN TOKYO

completed building, shown in Fig. 2, and a great deal of adjoining track and bridge work were completed last year.

The station was designed and erected under the direction of Kingo Tatsuno, an architect who studied for many years in the United States. It is 1,104 ft. long, from 66 to 132 ft. wide, and 54 ft. high in the main building, with domes at each end 152 ft. high.

The foundation is of concrete resting on wooden piles of an average diameter of 7 in., and from 18 to 24 ft. in length. They were all driven by hand, from eight to ten men and women being employed in driving each one; the average time of driving one was one-half hour. These piles were driven 2 ft. apart, and the tops after driving were 12 ft. below ground level. On them was placed 4 ft. of concrete, and the side and other walls were carried up to grade.

The building is of light steel-frame and reinforced-concrete construction, being faced with brick and trimmed with a fine quality of granite which is dressed to perfec-

*Tokyo, Japan.

tion. No better cut stonework being done in any portion of the world.

There are four front entrances; a center entrance for the exclusive use of the imperial household, a second at one end for incoming passengers, a third at the other end for outgoing passengers, and a fourth smaller entrance for urban electric-car passengers.

Ample provisions are made in the building for all classes of passenger traffic, and all are provided with waiting rooms, toilet and smoking rooms, restaurants and dining rooms. The ground floor is entirely for passenger traffic; the second floor is for dining rooms, restaurants and hotel accommodation in that part south of the imperial entrance, while that part north of the imperial entrance will be used for department offices and other work officially pertaining to the Department of Communication, as will all of the third floor.

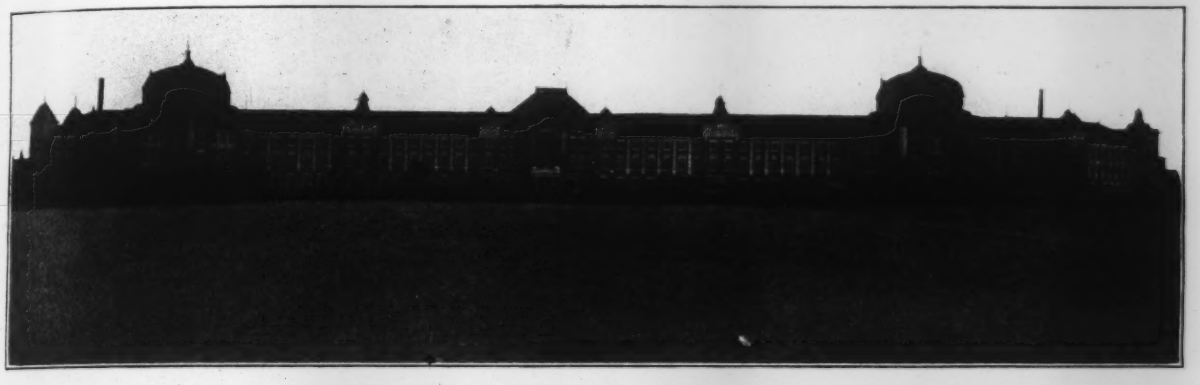


FIG. 2. FRONT VIEW OF THE NEW CENTRAL STATION OF THE IMPERIAL GOVERNMENT RAILWAYS OF JAPAN AT TOKYO

The interior finish of all parts of the ground floor except the imperial suite has wainscoting of marble and artificial stone, and the rest of the side walls are of wood. The ceilings are of Japanese plaster and decorations. The imperial suite is very handsomely decorated by the most eminent artists of Japan, the finish being in marbles, mosaics, rare woods and precious metals, the inlaid work being especially worthy of the highest praise. These rooms are entirely separated from the rest of the rooms, and none but members of the imperial household and their intimate attendants are ever allowed to enter them.

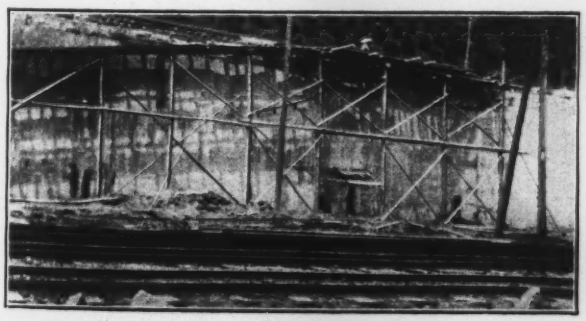


FIG. 3. CONCRETE RETAINING WALL, 1,600 FT. LONG, 39 FT. HIGH

No mechanical power was used in the construction of this wall. All concrete was wheeled in barrows up inclines similar to the one shown.

Baggage, delivery, telephone and telegraph rooms, cloak rooms and parcel rooms, and in fact all accommodations to be found in the best of modern passenger terminals have been provided, as it has been the aim of the department to construct a building and station second to none in the world and fully equipped in every particular for its purpose. The building is lighted by electricity and heated by steam, equipped with American elevators and planned on a basis of American efficiency. It is a credit to the people and the country.

The tracks and platforms are all elevated; access to and exit from them are by means of subways, the incoming and outbound platforms being entirely separate from each other, as are also the inbound and outbound urban-passenger platforms. A view of the track sheds is given in Fig. 1.

The cost of the building has been $1,350,000; the time used in building, estimated in days' labor, the usual method employed by the Japanese, mounts up to 730,000 laborer-days.

An average of 125,000 passengers will use this station daily, and the station master receives the magnificent salary of $60 gold per month. Common laborers on the building received 20c. per day of 10 to 12 hours, carpenters and masons $15 per month, and all other labor was paid in proportion. Very little power except human muscle was used in this work. In the wall shown in Fig. 3, for instance, all of the concrete was mixed by hand and wheeled in barrows up the inclines shown, even though the maximum height of the wall was 39 ft. In all of the bridge work, for grade crossings, no hoisting engines were used, although the heaviest girder reached 40 tons in weight.

The Deepest Well in the United States is said to be the 7,181-ft. well recently put down at McDonald, Penn., for the People's Natural Gas Co., of Pittsburgh, Penn. It ranks next to the 7,300-ft. well in Galicia, which is the deepest in the world. The diameter is 13 in. at the top and is reduced gradually to 5 in. at the bottom. The total weight of casing is 45 tons. A special feature is that the 22-ft. sections of casing were welded together by the oxyacetylene process of the Oxweld Acetylene Co. Two sections were welded on the ground, and the 44-ft. section then hoisted and welded to the top of the casing already driven, when the latter was about 5 ft. above ground. The casing was supported by clamps during the process, and these were not released until the weld was cool. The edges of the pipe were chamfered at 60° to give a deep and wide weld. Special precautions were taken to have the new section in exact alignment with the casing already driven. The welding took about 25 min., and 15 to 20 min. were allowed for cooling. The stress on the joints was relieved by putting a plug in the lower end of the casing so that the water in the well (under pressure) would support the casing. This was drilled out when the well was completed.

Cableway and Railway for the Ascent of Mont Blanc

Two projects are under way for railway lines which will eventually give access to the summit of Mont Blanc, the most notable of the Alpine peaks, and both of these are completed for the lower portion of the route.

The present line extends from Chamonix, Switzerland, for about half the full distance and ends in a steep-grade cableway to the summit of the Aiguille du Midi. The first two sections extend from Chamonix (3,280 ft.) to La Para (grades 15 to 60%) and to the Bossons glacier (average grade 65%), ending at an elevation of 8,202 ft. On these sections the cable is approximately parallel with the ground and is carried by steel towers or bents 33 to 80 ft. high, 132 to 295½ ft. apart; there are two spans of 657 ft. The next two sections are much steeper, with grades of 60 to 85%, and end at the Col du Midi (11,483 ft.).

The last section ascends to a bench about 160 ft. below the top of the Aiguille du Midi, the summit elevation of the line being 12,631 ft. From this, a line is proposed descending to the White Valley (11,693 ft.), where a pleasure resort may be established. The actual summit of Mont Blanc is at 15,974 elevation. The steep grade sections are very similar to the cableways ascending the Wetterhorn and the Bauerkohlern, several illustrations of which are on the opposite page.

Each car will be carried by a single cable (*A*, Fig. 2), instead of two cables, as originally proposed, as experiments have indicated the difficulty of distributing the load equally on two cables. The cables will be $^{25}/_{64}$-in. diameter, composed of ⅛-in. wires of crucible steel and having a weight of 11¼ lb. per ft. The tension device (with a 25-ton weight) is placed at the lower end of the incline, and is connected to the cable by a chain; two safety anchor cables are attached to the end of the main cable to prevent accident if the chain breaks.

There are two cars on each section (one ascending as the other descends), operated by the wire hauling cable *B*, $1\frac{5}{16}$-in. diameter, weighing 2.24 lb. per ft. and having an ultimate tensile strength of 135,000 lb. A similar cable *C* is provided for braking; a clamp brake *D* grips this if the hauling cable *B* should break. This brake is operated through the pull on the tail rope *D*, releasing a tripping gear which operates the tension rod *F*. The top of the suspension frame of the car is shown at *G*. At the lower stations the hauling and brake cables pass over large guide sheaves and then around [illegible] end pulleys, which are connected to the tension devi[illegible] The driving gear and pulleys are at the upper stati[illegible] All the cables and connections are designed with [illegible] factor of safety of 10.

Each car can carry 24 passengers (18 seated) and weighs four tons with full load. It is attached to an overhead truck running on the main cable, as shown in Fig. 2. The truck has four grooved wheels carried in two separate frames *H*, with holding-down springs and mechanism *J* to prevent the wheels from getting off the

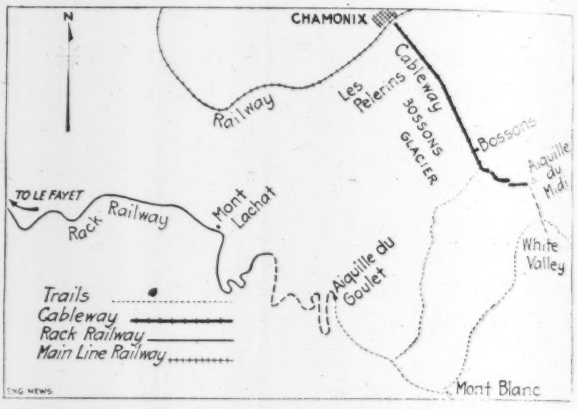


FIG. 1. ROUTES OF CABLEWAY AND RACK RAILWAY

cable. The guide sheaves *K*, beneath the carrying cable, engage it when the journal boxes of the truck axles reach the bottom of the vertical slots *L* in the pedestals. The distance between the cable and the guide sheaves is necessary to clear the cable supports on the towers. The speed will be about 500 ft. per min.

A government concession for a rack railway from Le Fayet to the summit of Mont Blanc was granted in 1904, and the first section was opened in 1909. The lower end is at an elevation of 1903 ft., and the section to the Gouter Summit is 11½ miles long, with a rise of 10,630 ft. The line is operated by steam locomotives at present, but is intended for electric operation. It has a gage of 3 ft. 3⅜ in., and its sharpest curves are of 164 ft. radius. It is laid with 40½-lb. rails, with 12 steel ties to a rail length of 34 ft. 6 in. The rack rails are of the Strub type, in lengths of 11 ft. 6 in. The last section, to the summit of Mont Blanc (15,800 ft.), will be 2½ miles long, with four tunnels aggregating two miles.

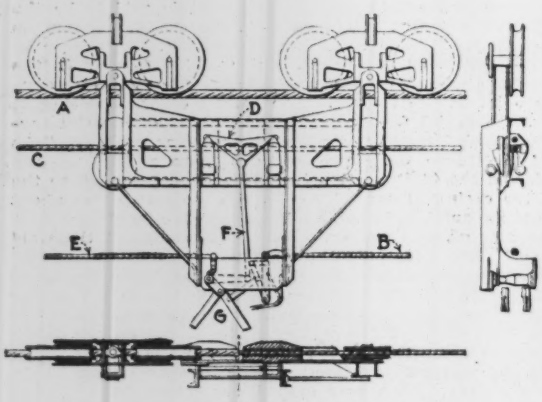


FIG. 2. CARRYING TRUCK OF CAR

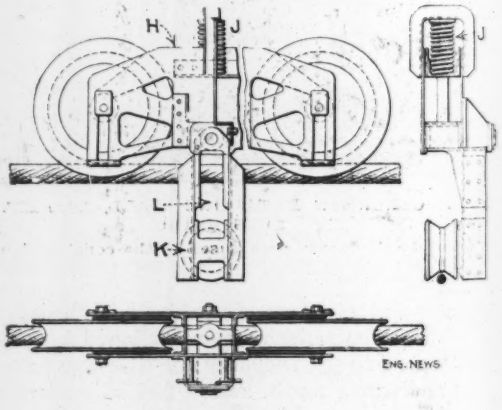


FIG. 3. DETAIL OF RUNNING GEAR

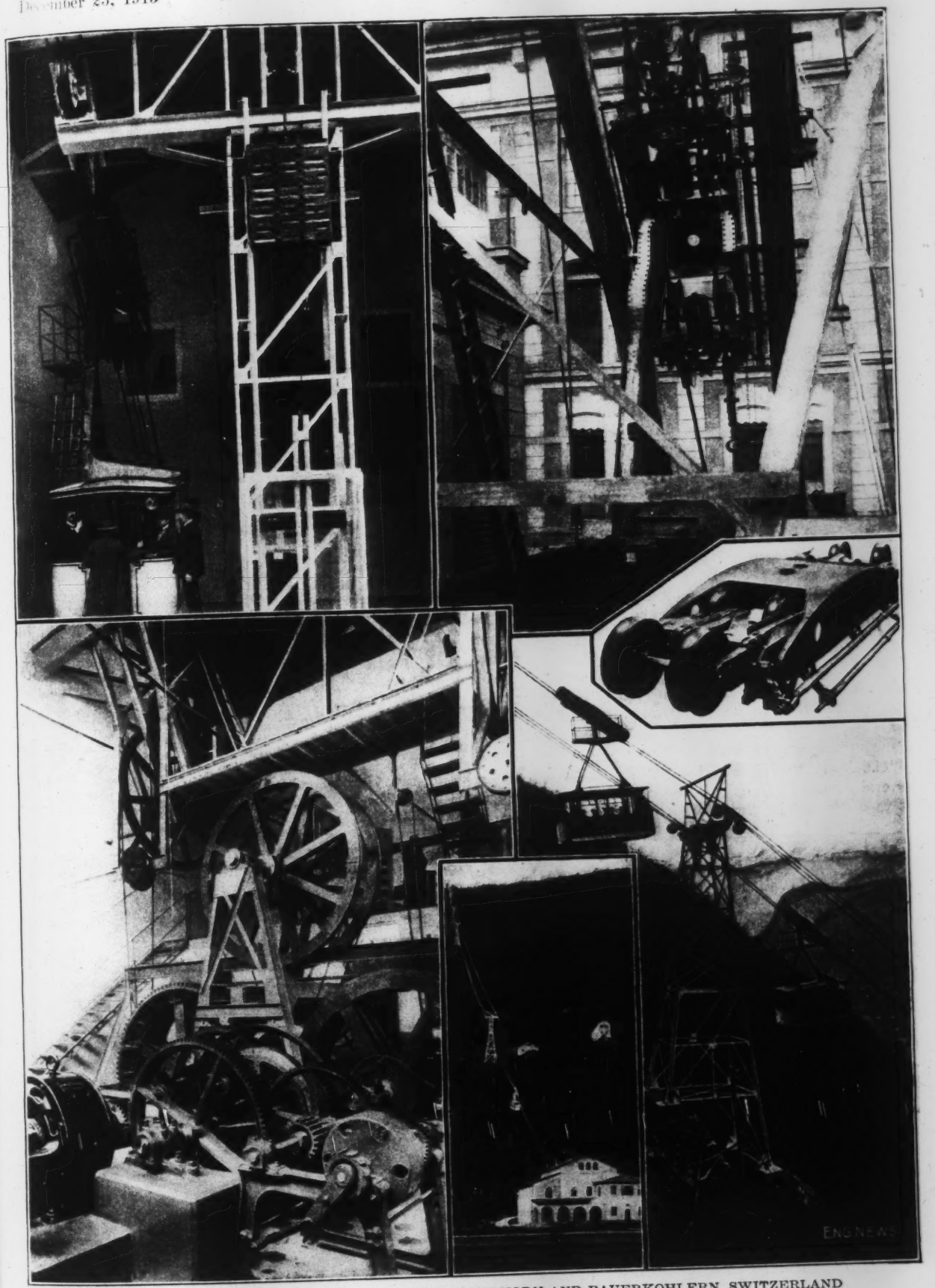


FIG. 4. PASSENGER CABLEWAYS AT THE WETTERHORN AND BAUERKOHLERN, SWITZERLAND

Meridian Park Retaining Wall at Washington, D. C.

Retaining-wall construction of somewhat unusual layout and rather ornamental design is now under way as a part of the new Meridian Park at the northern part of 16th St., Washington, D. C. The site is a sharp elevation of ground rising some 250 ft. above the general city level, where many years ago there existed a standpipe which supplied part of the City of Washington with water. Through the hill ran the Washington meridian, which at one time was used as a datum for observations in this country, and therefore the place received the local name, Meridian Hill. About 20 years ago the extension of the city led to the cutting of 16th St. through the hill, and that street, while still on a rather severe grade, is now from 30 to 40 ft. below the top of the hill, the cut being in a stiff clay which stands almost upright even after the many years since the cutting.

On account of the sightliness of the location and the growth of the high-class residential district in this direction, the government a few years ago purchased the city block comprising most of the hill. This block extended from W St. at the south to Euclid St. at the north and from 16th St. on the west to 15th St. on the east, being about 500 ft., 300 ft., 1,400 ft. and 1,400 ft. on these four respective sides. It is the intention to build here an elaborate park of the formal type, that is, heavily wooded, with gardens, walks, colonnades, fountains, waterfalls, etc. As a part of this work, which is expected to extend over a number of years, the retaining wall on the 16th St. side is now being built.

As shown in the drawing in Fig. 1, the wall is in two sections, partly to avoid the necessity of so high a wall as the total cut would require and partly in order to permit between the two walls a wooded interval which will obscure from the street the possibly offending expanse of the continuous upper wall.

The lower wall is about 1,303 ft. long, there being several gate and stairway openings besides this length, and it varies in height from 7 to 10 ft. It is divided into panels about 29 ft. long, the coping for each panel being level and the next higher wall rising in step fashion to conform with the grade of the street. Fig. 2 shows one of the completed panels. As shown in the section in Fig. 1, the wall is of the gravity type, reinforced slightly in the front and doweled to the continuous base. The panels are first cast with the reinforcing rods extending

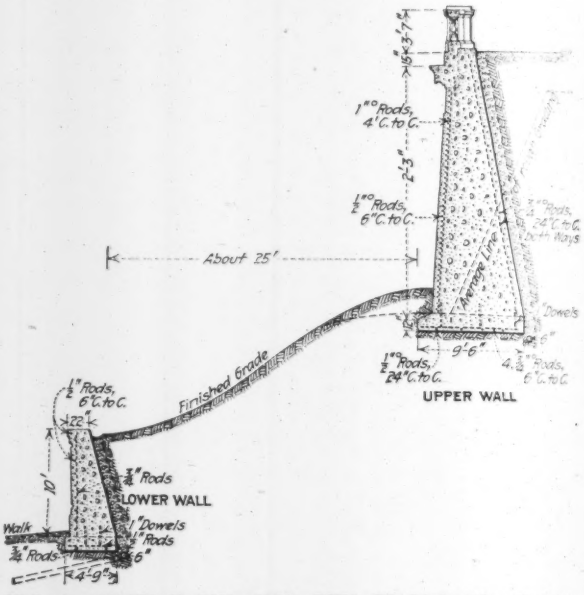


FIG. 1. SECTION THROUGH TWO WALLS ON 16TH ST. SIDE OF MERIDIAN PARK, WASHINGTON, D. C.

out into the pilaster space, and the pilaster is then poured after the wall section is completed.

After some experimenting both in drawings and on an actual section of the wall, the paneling shown in Fig. 2 was decided upon. The rough part of the main-wall section is a scrubbed pebble surface, and the smooth ribbon intermediate parts are rubbed to obtain that appearance. The pilasters, which are also an exposed pebble aggregate scrubbed to obtain a roughened surface, are

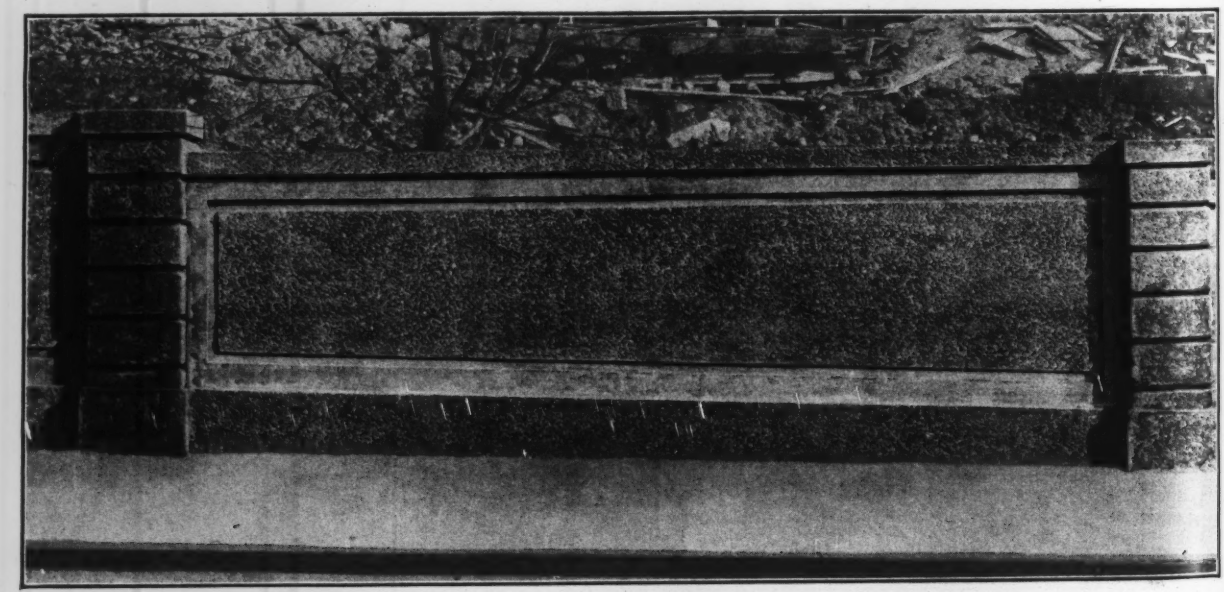


FIG. 2. NEAR VIEW OF A PANEL OF LOWER WALL AT MERIDIAN PARK

cast in plaster molds that are used over and over again. It was found that the plaster mold gave a much better edging for the quoins of the pilasters.

The wall is founded on the natural clay and is drained both at top and bottom. On account of the stiff grade down the hill, no great trouble is anticipated in watertightness, but the joints between the pilaster and the main section are heavily waterproofed with a pitch-and-felt application.

The upper wall is 280 ft. long and varies in height from 22 to 24 ft. It is set about 25 ft. back from the front wall and is founded on the clay. As shown in Fig. 3, the earth back of this wall stands almost vertically in the cut. However, the wall has been designed in gravity section (Fig. 1) to care for the thrust of the earth for the full height.

The wall is being built in 12 panels, each about 25 ft. long, with a close flush joint between panels. This joint is waterproofed. The sections are being set up alternately and the openings then filled in. The surface is of a plain rubbed face to agree with the lower wall,

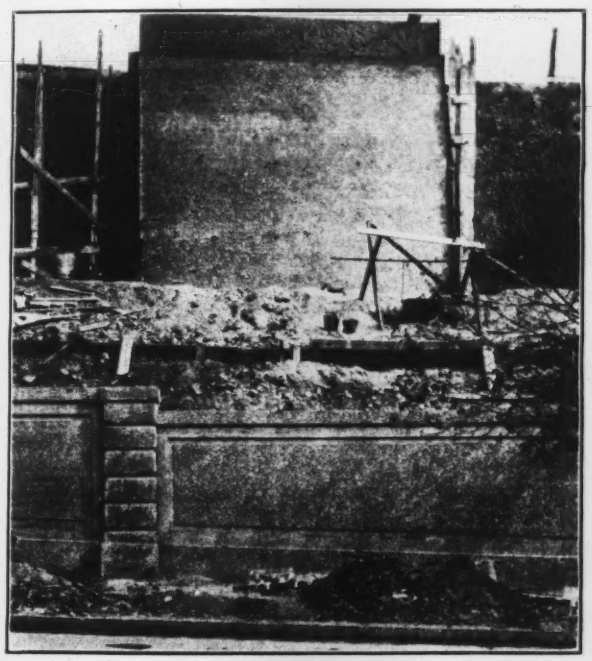


FIG. 3. LOWER WALL COMPLETE AND UPPER WALL UNDER CONSTRUCTION

and the top of the wall is to be capped with an ornamental balustrade of cast concrete.

All of this Meridian Park work is being done under the direction of Col. W. W. Harts, U. S. A., who is Superintendent of Buildings and Grounds, District of Columbia. The plans for the park were drawn by George Burnap, the landscape architect in Colonel Harts' office. The original estimates for the park improvement aggregate $310,000, of which $82,000 is for retaining walls, $118,000 for architectural work, $39,000 for soil and planting, $25,000 for roads and sidewalks, $19,000 for lighting, water and drainage and $27,000 for contingencies. The ground itself cost nearly half a million dollars. The contract is being carried out by the Boyle-Robertson Construction Co., of Washington, D. C.

Sewage-Treatment Works for Altamont Y. W. C. A. Camp

By Henry W. Taylor*

Unusual conditions required a complete system of sewage disposal for the Y. W. C. A. encampment at Altamont, N. Y., and the necessarily high degree of purification made imperative a design that would utilize local materials and avoid as far as possible the high cost of importing sand for sand filters.

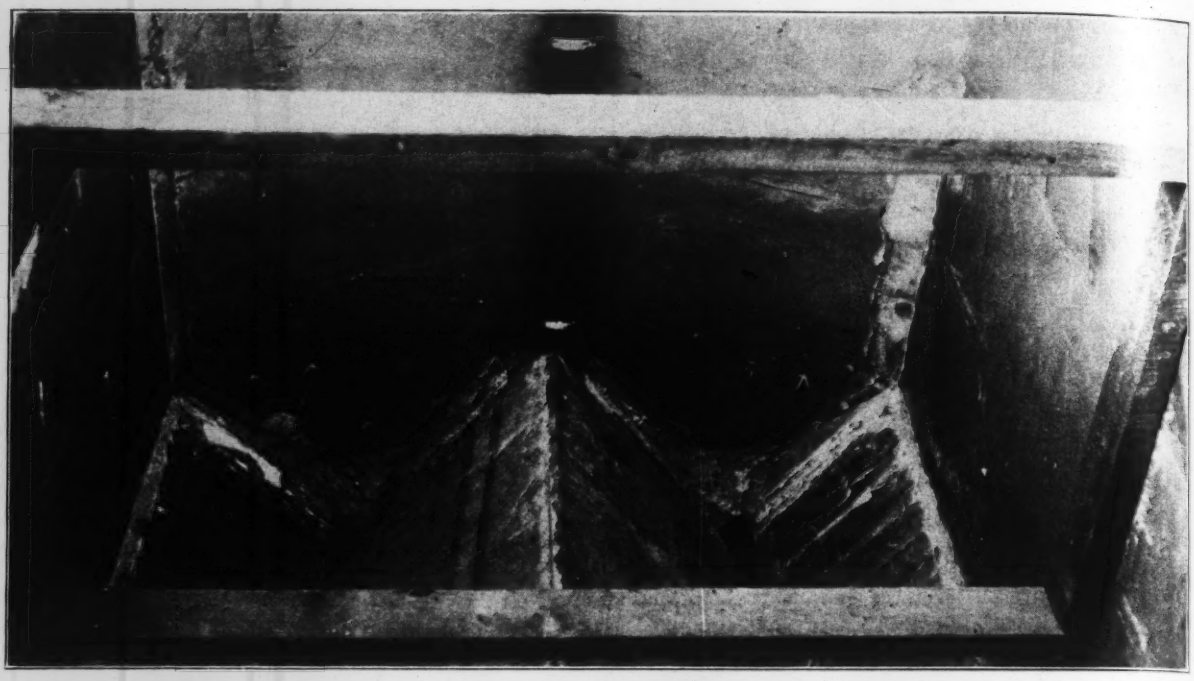
The Y. W. C. A. camp at Altamont is located on a slope of the Helderbergs, about 2 mi. from the Altamont Station and some 400 ft. above the valley level. Five buildings have to be served: A hospital, the main building, the laundry, and two separate water-closet buildings for the majority of the campers, who are housed in tents.

The feasibility of installing a subsoil irrigation system was first investigated, but the subsoil was found to be a stiff clay, underlain with rock. Even with 60 or 70 lin.ft. of drains per person served, the satisfactory operation of such a plant would be questionable. The fact that the disposal plant will not be used in winter was also an argument against the use of subsoil drains, as it was feared that, when not in use, the drains would be seriously disturbed by frost during winter weather. With a moderate footage of drain per person served by the plant, the expense of installing a subsoil system would have been over $3,000.

The small brook receiving the purified sewage flows through pasture lands below the camp and is dry the greater part of the summer. Sand filters were thus required, but no local sand could be obtained. The cost of importing sand led to primary filtration by a sprinkling filter, a small sand filter, and shallow absorption trenches for the sand-filter effluent.

The plant consists of a small circular Imhoff settling tank; a dosing tank; an elliptical sprinkling filter with two nozzles on the major axis; a combination final settling tank and sand-filter dosing chamber, with two alternating siphons; three sand filters 2½ ft. deep; 2,000 ft. of absorption trenches about 6 in. deep and lying above the clay subsoil. The plant will be in active operation for about four months of the year. The design is based on an average population of 200. The actual per capita water consumption is 30 gal. per day, but in designing the filters a people rate was used, since the organic matter to be treated is practically the same as in the case of a normal sewage containing about 100 gal. per capita. The Imhoff tank provides 6 hr. of detention for actual sewage flows. The sprinkling-filter dosing tank contains about 140 gal., and the special Miller siphon will discharge about 40 times per day. The sprinkling filter is 5½ to 6 ft. deep and will operate under a people rate of 18,000 to the acre, while the actual water rate will be less than 600,000 gal. per day per acre. The dosing chamber for the sand filters is designed with a capacity below the low-water line of the siphons, so that there still remains a half-hour detention for the sprinkling-filter effluent. A deep scum board prevents floating matters from reaching the siphons as the water level fluctuates. The sand filters will operate under a people rate of 5,000 per acre and

*Consulting Engineer, 100 State St., Albany, N. Y.



LOOKING DOWN INTO IMHOFF TANK AND SHOWING SLATE BAFFLES, Y. W. C. A. CAMP, ALTAMOUNT, N. Y.

an actual water rate of less than 170,000 gal. per acre per day. One of the three beds is always in reserve, while the shear-gate control of the siphon discharge permits any two of the beds to be used together in alternation.

As to the above rates, it will be noted that the plant is operated only in the midsummer and has a complete rest of eight months between periods of service. The sewage is of course extremely fresh and purely domestic. No lively septic action is expected in the short period of operation of the Imhoff tank, which will be completely emptied, at the end of the season, onto one of the sand-filter beds. Little deposit will be thrown off by the sprinkling filter except when the plant is first put into operation in June, at which time the remainder of the stone coatings from the last season will probably be flushed from the filter. The combination final settling tank and sand-filter dosing chamber will undoubtedly intercept some solids in the sprinkler effluent and a considerable amount of coagulated fats and greases, while the sewage reaching the sand filters should be comparatively high in oxygen values. Judged from the rates proposed in the past for the sand filtration of a sprinkling-filter effluent, the design is extremely conservative. However, a reasonable amount of drying and scraping of the sand filter is expected and has been allowed for.

The Imhoff tank was built of field-stone rubble. The sprinkling filter is exposed for its entire depth and built of a dry rubble wall with crushed field stone as a filtering medium. Dosing chambers were built of concrete, using crushed field-stone and imported sand aggregate. The baffle walls (see view) of the Imhoff tank consist of 1-in. slate slabs, supported by the tank walls, piers and a diametric wall, the piers and central wall being of brick. Two men laid the brick and placed the slabs in two days. Any other form of baffle construction would have been very expensive and would have required other than local labor. The rubble wall for the sprinkling filter also proved very economical. It provides a filter aërated throughout its depth and presents a creditable appearance.

The work was done under the direction of the local superintendent of the camp and under the general supervision of the engineer. The actual cost of construction of the plant, together with 1,500 ft. of 6-in. sewer, was about $1,470. The sand cost about $2.50 per cu.yd. in place and was shipped from Ballston. If a sand filter had been used without the intermediate sprinkling filter, a rate of not over 1,000 people per acre would have been permissible with an institutional plant, and the sand alone for such a plant would have cost over $2,500. The sprinkler filter complete cost little, as the local stone could be used for concrete floor, rubble wall and filtering medium.

The absorption trenches will be plowed out in the shallow topsoil in an area below the sand filters. This topsoil will absorb, during dry weather, a considerable amount of the plant effluent through vegetable absorption and evaporation. During dry periods a further absorption will take place in the bed of the brook between the point of the plant discharge and the pasture lands below. This absorption will be made possible by the removal of solid matter, especially greases and fats, which in a crude sewage would waterproof the absorption area and give rise to deposits and odors. During wet summer seasons the plant effluent will be diluted about 3 to 1 by the flow of the brook.

Brick and Tile Production in the United States in 1914 amounted to $129,588,000. This was a considerable decrease from 1913, when the value was over $143,000,000. The most important clay product is common building brick, of which nearly $44,000,000 worth was produced in 1914. The value of the firebrick produced was $16,500,000; sewer pipe, $14,000,000; vitrified paving brick, $12,500,000; drain tile, $8,500,000, and fire-proofing material, $8,400,000.

Monumental Timber Building Endangered by Rot

The Forestry Building, constructed at the Alaska-Yukon-Pacific Exposition in Seattle in 1909, the Forestry Building of the Lewis and Clark Fair at Portland, built some years before, and the Oregon Building at the Panama-Pacific Exposition in San Francisco, were all of the same type of construction, having colonnades formed of huge logs with the bark on.

The one at Seattle, shown on this page, became the property of the University of Washington and has been used as a museum by that institution. The building is 312 ft. long, 128 ft. wide and 90 ft. high, contains over 2,000,000 ft. of logs and lumber, about 300,000 cedar shingles, and is the greatest building of the kind ever constructed. There are 126 main columns of Douglas fir, which are from 42 to 54 ft. in height, 5 to 6 ft. in diameter, with an average weight of 25 tons.

The timber foundations began to decay a year or two ago. James J. Hill, of the Great Northern Ry., donated $5,000 to make repairs to the building. Now the decay has extended to the columns and the building itself.

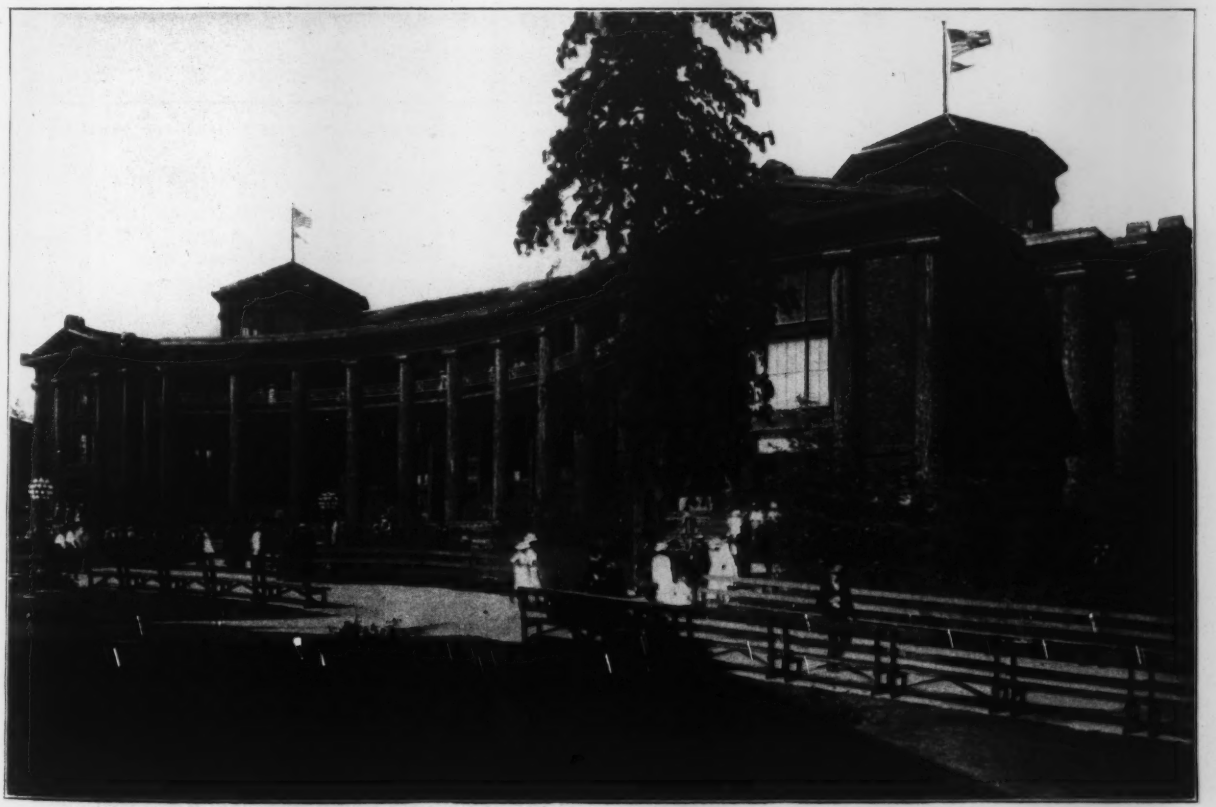
The columns were first affected by the bark beetle. Prof. Trevor Kincaid proposed warming the building to kill them; while this seemed to cure the beetle trouble, it only accelerated the decay and rotting of the columns.

The rotting of the columns is due to the same fungus that is found in lumber piles, favored by moisture and débris. The inside rows of columns in the building have been acted on much more rapidly than the outside ones, due to the heating of the museum. Humphrey, of the University of Wisconsin, has been investigating this class of fungi and the cure for it. The Portland building has been acted on to some extent, although not so badly (as it is not heated). So far nothing has availed to cure the trouble.

The various departments at the university have made reports on the subject. It has been proposed to replace the columns by treated timber ones, and also to reproduce the columns in concrete. The latter scheme has not met with favor from the lumbermen of the state, but that it provides a very pleasing solution is demonstrated by some similar reproductions of rustic wood in arbors on the grounds of R. P. Butchart, manager of the Vancouver Portland Cement Co., near Victoria, B. C., where the bark, knots and worm holes are so faithfully reproduced as almost to defy detection.

A report of Prof. E. O. Eastwood, of the engineering department, just filed with the Board of Regents, recommends that all rotted caps and sills be replaced and the cavities in the columns filled with concrete to keep out the air. The prevention of future decay will probably be taken care of by boring the columns at various points and injecting sulphate of copper. Some of the columns will be so treated as an experiment, as it will be of great value to the lumber interests if some effective method of treating large timbers cheaply to protect from dry rot is found.

It may be remarked incidentally that, however interesting such a building is as a spectacle at an exposition, it is far from being a very useful type of building for a university, so that its eventual decay and demolition will be no serious matter, except for the cost of replacement.



FORESTRY BUILDING AT UNIVERSITY OF WASHINGTON IN SERIOUS CONDITION FROM DECAY

Severe Earthquake in Nevada

By H. P. Boardman*

Several earthquake shocks were felt in northern Nevada on Oct. 2, 1915. The first pronounced shock felt in Reno was about 4 p.m.; the next shortly before 6, and the third and heaviest about 10:50 p.m. This last shock was of about 45 sec. duration and of intensity VI according to the Rossi-Forel scale, causing general awakening of those asleep, oscillation of chandeliers, etc. Many persons left the buildings they were in.

On the University of Nevada seismograph the pointer moved nearly equal amounts in all directions but rather more pronounced easterly and westerly, and the chandeliers noticed were swinging in an easterly and westerly direction. A report was circulated the next day that the center of disturbance was in the Wasatch Mountains in Utah, but this was a mistake. The fault where the earth movement occurred is located in north central Nevada, south of Winnemucca, and about 140 mi. northeasterly from Reno.

It will be evident from the views shown herewith that if the fault had occurred near a large city the damage to property, and probably loss of life, would have been great. Many chimneys and the end of one building were shaken down in Winnemucca, a town of about 2,000 population. Several water tanks along the Southern Pacific railroad were shaken down.

The writer, in company with Prof. J. C. Jones, head of the department of geology of the University of Nevada, visited the fault at several points on Oct. 9 and 10, one week after the earthquake, and took a number of photographs, a few of which are herewith shown.

Location of the Fault

The fault extends for a distance of 25 or 30 mi. along the west base of a southern spur of the Sonoma range of mountains on the east side of Pleasant Valley, which valley is about 1½ to 4 mi. wide and lies in a direction about N 10° W. and S 10° E. The valley slopes gradually to the south and is bounded on the west by the East Humboldt range of mountains, commonly called the East Range. North of Pleasant Valley lies a similar valley, somewhat wider, called Grass Valley, which has a slight slope to the northward toward the Humboldt River, into which it drains when there is sufficient running water to flow that far.

An old fault scarp, much like a terrace but now eroded, is plainly visible for miles along the west base of the Sonoma range on the east side of Grass Valley. At Hot Springs near the low divide between Grass Valley and Pleasant Valley this fault scarp curves out into the valley a mile or more away from the real base of the mountains.

The maximum displacement of the fault of Oct. 2 is at Pierce's ranch, 40 mi. south of Winnemucca and about midway of the fault. Fig. 1 distinctly shows the line of the fault along the talus slope from 1 to 2 mi. north of Pierce's ranch. The photograph was taken from a distance of about 2 mi.

Fig. 2 shows a waterfall of about 10 ft. at Pierce's ranch, created by the fault. We were informed that about three-fourths of the water in this stream is "new," coming from a spring opened up by the earthquake about 4 mi. up the cañon at a point beyond the upper spring that formerly fed this stream. The water was still nearly black with loamy sediment when we were there one week after the earthquake. It is interesting in this connection to note that the State Engineer has received a great many filings since the earthquake on new water rights developed in that part of the state. Ground water and wells were affected in some cases more than 100 mi. from the fault, many of these effects no doubt being only temporary.

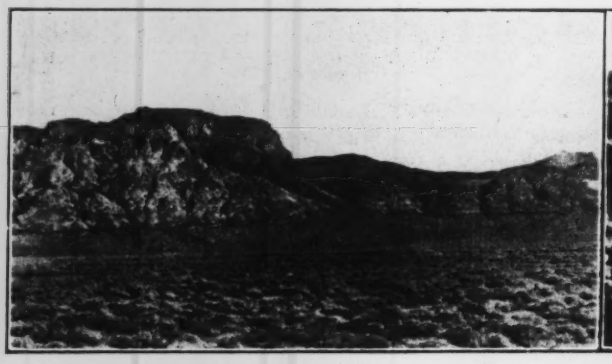


FIG. 1. EARTHQUAKE FAULT ALONG TALUS AT BASE OF SONOMA MOUNTAINS

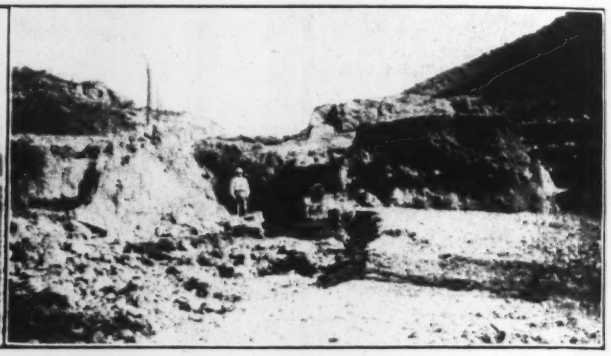


FIG. 2. WATERFALL OF 10-FT. HEIGHT FORMED BY FAULT.

Fig. 3 shows the shattered condition of the ground about 100 ft. from the waterfall, which was just to the right of the picture. The leaning of the tree toward the fault was caused by the movement of the ground in which it grew. The tree at the left of the picture was plumb.

Fig. 4 shows the front wall of a dug-out storage house, or cellar, about 200 ft. south of the waterfall. It was evidently too close to the fault to be injured seriously, as only a few stones were shaken from the wall.

Fig. 5 is also at Pierce's ranch, and the vertical displacement of the fault within the limits of this picture ranges from 10 to 15 ft. The fence line, though pulled in two, lined up perfectly straight on opposite sides of the fault as nearly as could be determined by the eye, indicating no horizontal shearing along the fault.

The dip of the "slickenside," seen at the bottom of the fence post in Fig. 6, was about 54°. This post belonged to the fence shown in Fig. 5.

The wrecked barn shown in Fig. 8 is at Pierce's ranch and about 700 ft. from the fault. No other buildings

*Professor of Civil Engineering, University of Nevada, Reno, Nev.

at this ranch were badly damaged, and in fact no frame buildings in the valley were seen that had been seriously damaged, though one small cabin was moved about 9 in. on its foundation. On the other hand practically all the stone-masonry structures in the valley were wrecked except the one shown in Fig. 4.

There was a new concrete house at Cooper's ranch, 18 mi. south of Pierce's and on the other side of the valley, about 3 mi. from the fault. The ground under this house was cracked, and the house was moved forward downhill about 8 in. The rear wall hung back on the foundation at the center, and the effect of this on one of the inside partitions is shown in Fig. 7. The north wall is cracked from the ground to a window and above the window. The ground, foundation and house all moved together from the crack in the ground, which was nearer the rear of the house than the front. An old frame house near the cement house standing on posts about 2 ft. high, was not damaged. The ground cracks did not open up near it.

The ground in the valley near Cooper's ranch and for 10 mi. north of it was very much more cracked and loosened up than in the northern part of the valley. In many places our auto passed over cracks several inches

FIG. 8. BARN WRECKED BY EARTHQUAKE

at Kennedy, extending over a period of two weeks or more, but so far as known, no independent fault has opened up to the surface near Kennedy.

This remarkable fault is interpreted by Professor Jones as confirming his ideas of the origin of most of the interior mountain ranges of Nevada, that is, that they were in the main caused by faulting. He states that this theory is concurred in by most geologists who have made a personal study of field geology in this locality.

FIG. 3. GROUND CRACKS IN FLOOR OF VALLEY NEAR WATERFALL

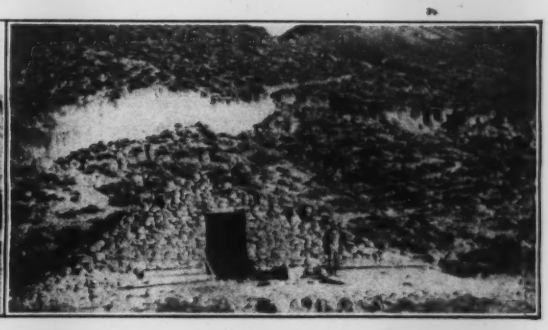


FIG. 4. UNINJURED STORAGE CELLAR CLOSE TO FAULT

wide crossing the road, the vertical displacement being often from 6 to 18 in. From many of these cracks, ground water found a temporary outlet but had stopped flowing in most cases before our arrival.

Kennedy, a mining camp on the east slope of the East Range about 15 mi. southwest of Pierce's ranch, was badly shaken up but had no frame buildings wrecked. A great many minor quakes followed the main severe shock

The writer does not recollect having heard of another earthquake fault of such magnitude occurring so far inland (more than 350 mi.), though such faults doubtless have occurred within historic times and certainly in geologically recent times. There are traditions that a severe earthquake occurred in this same region 40 or 50 years ago, and it may have been at that time that one of the old fault scarps still to be seen was formed.

FIGS. 5 AND 6. FENCE CROSSING FAULT; TRENCH AT FENCE CROSSING

FIG. 7. CRACK IN HOUSE

Constructing a Large Concrete Sewer at Chicago

SYNOPSIS—To check sewage pollution of the lower end of Lake Michigan a 70-mi. concrete sewer, 11 to 16 ft. in diameter, is being built from South Chicago through the Calumet district to a pumping station, whence the sewage will be pumped to the drainage canal. The sewer and its construction methods are described.

The Calumet intercepting sewer is being built to prevent the pollution of Lake Michigan by sewage now discharged into the Calumet River in the southern part of Chicago. It will divert all the domestic sewage of this district and deliver it to the Sag Canal at the controlling works near Blue Island, whence it will flow to the Chicago Drainage Canal. A pumping station with a lift of 20 ft. and a capacity of 1,050 cu.ft. per sec., near the west end of the sewer, will raise the sewage and deliver it through 2 mi. of outfall sewer to the canal. The interceptor has a flow capacity of 1,050 cu.ft. per sec. and will serve an area of about 10,940 acres.

The total length will be over 10 mi. and the cost approximately $3,800,000. The location is shown in Fig. 1. The sewers in South Chicago, with the connection at the east end to the existing 95th St. pumping station, constitute section No. 1. Sections 2 and 3 extend from 97th St. and Baltimore Ave. to Stoney Island Ave. near 101st St.

The sewer will be of horseshoe section (Fig. 2), 11 ft. wide and 8.8 ft. high for the first 4,345 ft., 13x10.4 ft.

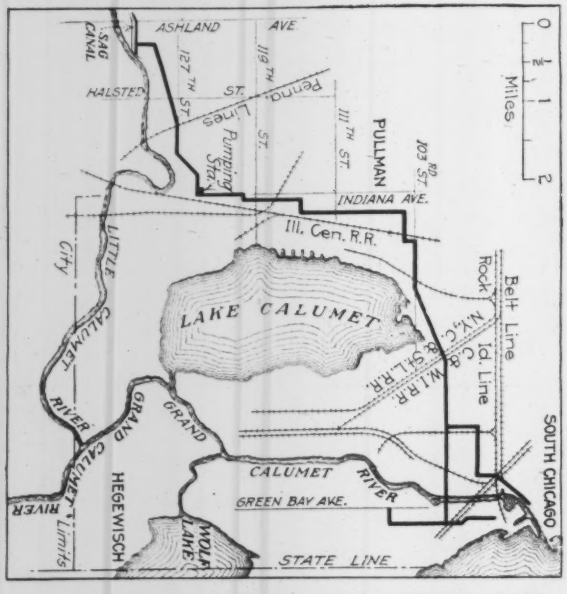


FIG. 1. MAP OF CALUMET INTERCEPTING SEWER

for 7,745 ft. and then 16.5x13.2 ft. to the end. The grade is 0.4 per 1,000 in the 11-ft. section and 0.2 in the larger sections. The construction is of monolithic concrete, reinforced with steel rods in the bottom where soft ground is encountered and with rods in the arch where the sewer passes under railway tracks. Manholes at one side of the arch are provided at intervals of about 600 ft.

The contracts for sections Nos. 2 and 3 have been let to the Byrnes Brothers Dredging and Engineering Co., No. 2, 4,345 ft. of 11-ft. sewer, $195,583; No. 3, 7,738 ft. of 13-ft. sewer, $331,882. The entire work is under the direction of George M. Wisner, Chief Engineer of the Sanitary District of Chicago; Langdon Pearse, Division Engineer, and H. R. Abbott, Resident Engineer. R. E. Harmon is the engineer in charge of the foregoing contract sections.

The following particulars relate to the construction of section No. 3—7,738 ft. of 13x10.4-ft. sewer. This work is in low-lying ground, swampy on the surface and underlain by stiff blue clay.

The arrangement of the construction plant is shown in Fig. 3. It is located adjacent to the New York, Chi-

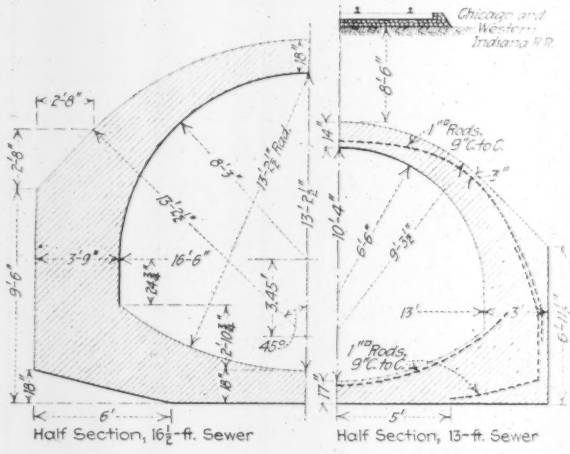


FIG. 2. CROSS-SECTIONS OF INTERCEPTING SEWER

cago & St. Louis R.R., a siding from which serves as the material track. Broken stone is dumped near one end of this siding, and beyond this is a line of bins (the bottom of which is about level with the tops of the gondola cars), into which both sand and stone are shoveled from the cars.

An interesting feature is the introduction of a mechanical unloader to replace hand shoveling of the sand and stone; but this was not put in service until a good part of the work was done. It consists of a traveling tower spanning the supply track and cars and carrying a vertical chain-and-bucket conveyor which can be lowered into the car. The conveyor delivers the material to a horizontal belt conveyor, which discharges into the sand or stone bins. This was designed by A. B. Seavern and has been used for unloading cars at railway coaling stations (*Engineering News*, Aug. 12, 1915).

Concrete materials are hauled from the loading bins alongside the material track in ¾-yd. steel side-dump cars on an industrial track of 20-in. gage. These cars were purchased by the contractor from the Panama Canal and had been used by the French in their early work on the canal. They are of French make (Decauville type), with shallow flat-bottom bodies, having a drop door on the dumping side. The cars were gaged and marked to facili-

fate loading, each car containing material for one batch of concrete.

Empty cars are pushed by hand on the track under the bins and receive stone and sand through sliding doors. Sometimes stone is shoveled by hand from the pile near

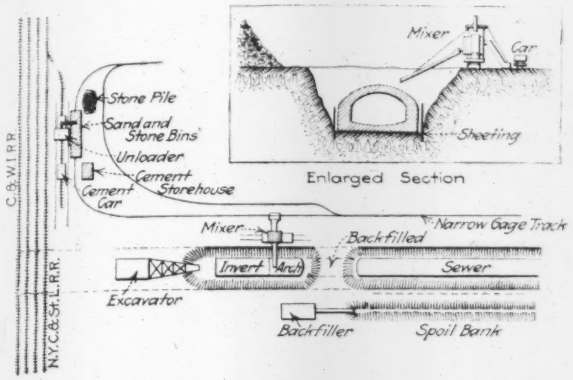


FIG. 3. CONSTRUCTION-PLANT LAYOUT, CALUMET INTERCEPTING SEWER

the bins. The car then receives three bags of cement, emptied into it from the storehouse or from a box-car on the material track. Trains of seven cars are hauled to and from the mixer by a mule.

Concreting the Sewer

A Foote concrete mixer with steam engine, vertical boiler and ¾-yd. drum travels on a track along one side of the cut. Material is supplied by the dump cars, each car having stone, sand and cement for one charge. The charging hopper swings down at the side of the supply track and the car is dumped directly into it.

The concrete is spouted into place, the chute having two hinged sections, which are thrown up successively to shorten the chute as the concreting approaches the top of the arch. The chute has a comparatively slight incline when the top of the arch is reached, and men have to push the concrete along it with spades. The concrete mix is 1:2:4.

The specifications allow the use of steel or wood forms for the arch. At the start the contractor used wood sheets supported on steel ribs. The sheets are built up of four or more pieces fastened together by cleats. The arch lagging is 2x6 in., beveled, and well greased on the outer face. For the remainder of the work, however, arrangements have been made to try the Hydraulic Pressed Steel Co.'s forms, consisting of steel ribs and wood panels faced with steel plate. The invert is built in wood forms and is poured first, in lengths of about 25 ft. at a time. After this has set for 24 hr., the steel ribs of the arch forms are erected upon it. The sides and arch are poured at one time.

Excavating and Backfilling the Trench

The excavation is done by a steam dragline excavator traveling ahead along the center line of the work and operating a 2-yd. bucket. It makes a cut about 40 ft. wide on top, 19 ft. wide on the bottom and 15 ft. deep, with the lower part of the sides practically vertical. The material is a peat formation on top, the rest of the cut being in stiff blue clay which has very little water and makes hard digging. The leveling of the bottom and trimming of the sides are done by shovels and mattocks. Timber sheeting in 6-ft. lengths is placed at the sides in the bottom of the cut and held by cross-timbers and trench braces. The spoil bank is along one side of the cut, and a backfiller travels along the center line of this bank. This machine was rigged up on the work and consists of a steam derrick traveling on rollers and having a 50-ft. boom with 1½-yd. grab bucket.

The west end of the section, where work was commenced, is just north of Lake Calumet. A ditch was dug for drainage purposes and serves to bring water to a pump house, from which it is delivered to a pipe extending along the cut to supply the tanks of the mixer, excavator and backfiller.

Portage Railway in Canada

A portage railway on Grand Island in the Athabasca River, Canada, is said to show a profit of $1,000,000 in 60 years' service, while its cost (including equipment) was less than $1,000. The railway is ¼ mi. long and enables river traffic to avoid dangerous rapids. It was built by the Hudson Bay Co., which owns it, and serves to handle the freight and provisions going in to supply the fur traders and prospectors and to carry the valuable outward shipments of furs, etc.

The track consists of strap or bar-iron rails on wood stringers laid upon wood ties. The equipment consists of two flat cars. The freight rate is $2.50 per ton, the men handling their own goods and shoving the cars along the line. One man collects the money and keeps the line in repair.

A scow going inland (downstream) lands its cargo at the upper end of the island and then goes down the rapids in about 70 sec. The vertical descent is about 65 ft. In the quiet (but swift) water below, the crew hold the boat with the oars till they can pick up a timber

PORTAGE RAILWAY ON GRAND ISLAND, ATHABASCA RIVER

thrown out from shore and attached to a light line. With this a heavier cable is pulled out, and the boat then hauled to shore for reloading. A boat coming out upstream is either taken through the rapids by tracking or is hauled across on the railway. The charge for the latter is $10.

A New Labor Law in Portugal has been enacted calling for a 10-hr. day in mercantile establishments, 7 hr. in banks and business offices, 10 hr. in general industries and 8 hr. in shops or works under the immediate supervision of the state or in underground work, as mining, and in industrial works dealing in poisonous or unhealthful materials. Other sections of the law provide for inspection of premises, limit the amount of night work and overtime and specify the rate of pay for overtime.

Field and Office

Building 50,000-Gal. Concrete Standpipe in 40 Hours

By George A. Sampson*

A reinforced-concrete standpipe 14½ ft. in inside diameter, about 40 ft. high and of 50,000-gal. capacity was recently completed at Merrimack, N. H., in less than

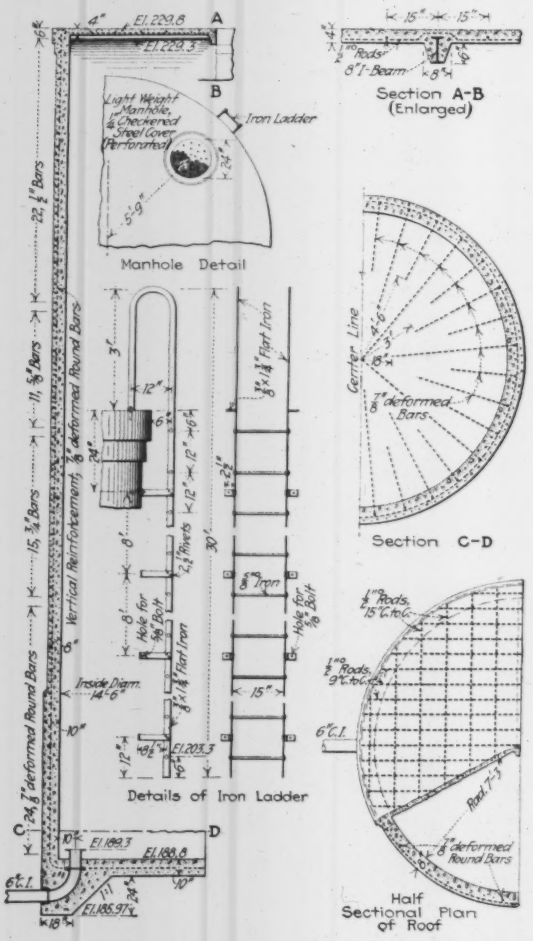


FIG. 1. DETAILS OF 50,000-GAL. REINFORCED-CONCRETE STANDPIPE, MERRIMACK, N. H.

5 days. Instead of building the structure in successive rings of concrete, the pouring was done in one continuous operation, which lasted just 39½ hr.

The illustration shows the essential dimensions. The maximum tensile stress in the concrete at the bottom of the cylindrical wall, assuming the concrete to take the entire pressure, is 155 lb. per sq.in.; in the steel, if it takes the pressure alone, 14,200 lb. per sq.in. With both concrete and steel taking the pressure the stresses are 140 and 1,400 lb. per sq.in. respectively.

*Civil Engineer, 14 Beacon St., Boston, Mass.

A clean, well-graded sand was obtained in the excavation for the standpipe. Briquettes made of this sand compared with those made of standard Ottawa sand had a tensile strength of 105.4% and 88.3% of the latter for the 7- and 28-day periods respectively. The coarse aggregate was gravel obtained from a ditch about 1 mi. distant, screened to give stone varying in size from ¼ to 2½ in. The gravel was washed at the time concrete was being mixed by a stream from a hose and buckets of water poured over wheelbarrows with perforated bottoms. Concrete for the wall was mixed 1 : 1½ : 3.

After the excavation was completed, the first step in construction was the placing of a 2-in. layer of concrete as a working base to aid in the erection of the floor reinforcement and outside form. The outside form was then erected to within a foot of the top and thoroughly braced to eight long telephone poles, erected around the circumference and tied together and cross-braced to insure rigidity. The next step was the placing of the steel reinforcement in the floor and wall. In the meantime the entire inside form was constructed in sections 8 ft. in height and in 10-ft. circular segments, ready for instant erection.

The mixing was done by hand, each batch being turned over at least six times in addition to the various operations of placing the concrete. After mixing, the concrete was elevated by means of a swivel hoist operated by two horses and dumped upon a platform at the top of the structure (see Fig. 2). It was then dropped through a wooden chute upon an inside working platform resting on top of the forms of each section as the work advanced. From this platform the concrete was deposited in the forms by shovels and thoroughly spaded.

The floor was poured on a Friday afternoon and the first section of the inside forms was erected on Saturday. No bolts, wires or other ties that would remain in the concrete were used to secure the forms. The concreting of the wall was started at 4:30 a.m. on Monday. During the day two 8-ft. sections were completed and another section of forms was erected, which was filled during the

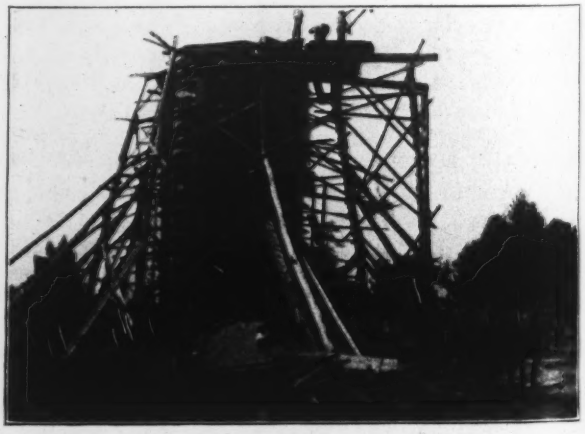


FIG. 2. STANDPIPE UNDER CONSTRUCTION AT MERRIMACK, N. H.

night. The remaining two sections were finished at 8 p.m. the following day, thus making 39½ hr. the total time for concreting the entire wall of the standpipe. At no stage during the casting of the wall did an hour elapse between successive layers of concrete, which was well within the time of initial set. The coping course and

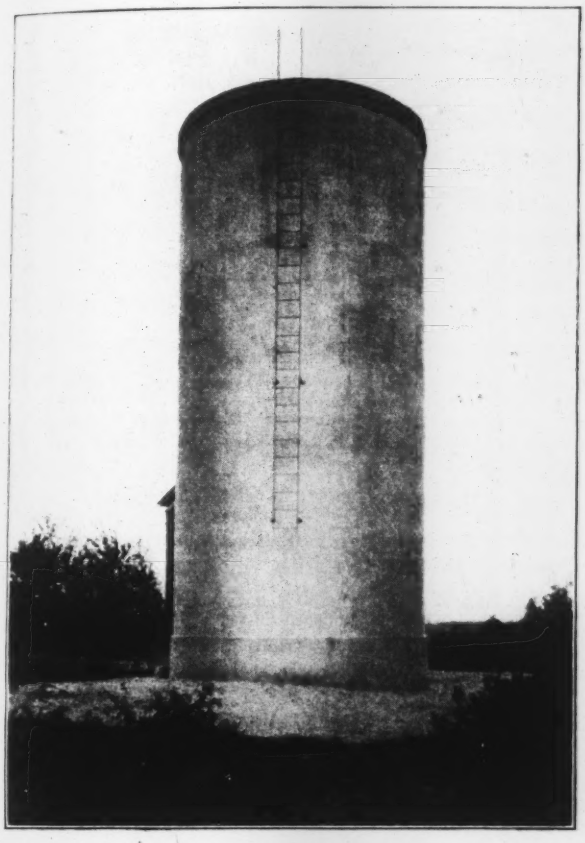


FIG. 3. COMPLETED STANDPIPE: 14½x40 FT., 50,000-GAL. CAPACITY; MERRIMACK, N. H.

roof were constructed Thursday afternoon, so that the whole structure was completed in five working days.

The outside forms were removed on the following Sunday and the surface was wetted and rubbed with a carborundum block to present a uniform appearance, after which a thin brush coat of cement-grout was applied and the surface again rubbed with the carborundum, followed by a dry brush. The total cost of the above-cited treatment of the outside surface was about $20. As soon as the finishing was completed the wall was wetted and kept moist for a period of two weeks.

The standpipe was filled 30 days after the wall was finished and the only leak was about halfway up for a distance of 15 ft. horizontally, where improper spading gave a slightly porous concrete, which was noted on the removal of the forms. There were also a few small damp spots about 4 in. in diameter, which were not visible leaks and were allowed under the terms of the contract.

The water was drawn off and the inside surface at the plane of leakage and wherever any dampness appeared on the outside was treated with waterproofing materials manufactured by the Arco Co., of Cleveland, Ohio. About 400 sq.ft. was waterproofed, at a cost of $23 for materials and labor. The tank was refilled and was found to be water-tight. Fig. 3 shows the finished standpipe filled with water.

The contract included a deferrization plant and laying of water mains for the water-supply of Merrimack. Robert Spurr Weston was consulting sanitary engineer for the W. H. McElwain Co., owner of the water-works. The contractor was the M. W. Allen Construction Co., of Walpole, Mass. R. E. Whitney was resident engineer and the writer was responsible for the design and construction of the standpipe. The contract price for the monolithic standpipe was $1,821, which was $175 more than the price originally agreed on for a structure built in the usual manner of successive 4-ft. rings.

Large Saving in Roof Steel by Cantilevering Purlins

By J. P. Sartz*

The following method of construction has enabled me to save a considerable amount of steel on roofs of factory buildings and may be applied to any roof or floor where the beams rest on top of the girders.

Let me, for an example, take a roof with trusses 20 ft. on centers, purlins 5 ft. apart, carrying a load of 75 lb. per sq.ft. Using the ordinary method, the purlins would be 20-in. channels, 20½ lb. per ft., as shown in Fig. 1. My method, Fig. 2, reduces the distance between supports to 16½ ft. by cantilevering a 9-in. 21-lb. I on both sides of the truss, making it possible to use a 9-in. 13¼-lb. channel. The purlins for the end-

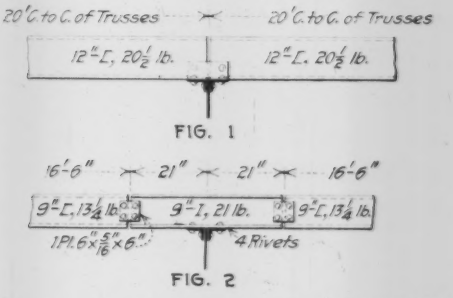


FIG. 1

FIG. 2

FIGS. 1 AND 2. ORDINARY AND CANTILEVER ARRANGEMENT OF PURLINS

panels will be 9-in. 21-lb. I's, cantilevering 1 ft. 9 in. over the first truss.

Certain points about this kind of construction may at first glance look doubtful, but careful calculations prove it to be perfectly safe and sound, and the economy of it is of course self-evident.

On the roof of a building 80x240 ft. I saved over 11 tons by using this method.

[Cantilever purlins are the regular thing in German structural practice—or were before the war. The usual arrangement is to make alternate bays cantilever and suspended spans, thus making the short piece of Fig. 2 part of the one adjoining span. Cantilever construction is considered preferable to relying on continuity. In the United States purlins are always proportioned for simple-span bending, though often placed in lengths covering several bays.—Editor.]

*Chief Structural Engineer, North China Department, Standard Oil Co., Shanghai, China.

Successful Soil-Sampling Tools

By Arthur M. Shaw*

In the examination of marsh lands in the lower Mississippi Delta with a view to their reclamation for agricultural purposes, the engineer often has occasion to make a detailed study of the soil and subsoil conditions. These have a bearing not only on agricultural problems, but also on the design and location of levees, canals and pumping stations. For the purpose of making such examinations the writer has had occasion to make frequent use of two devices which are especially well adapted to local conditions. It is not claimed that either device is original with the writer; in fact the soil auger in some form or other is used in all sections of the country.

Soil Auger for Taking Samples Below Surface

The economical construction of satisfactory levees requires that an examination of the soil be made at frequent intervals along the proposed route. Usually this will not require examinations to depths exceeding 8 or 10 ft. For this purpose an auger that will retain samples from various depths is most convenient. A satisfactory outfit used by the writer comprises the following material:

One 1½-in. Snell ship auger with screw. Upset stem, cut off to 18 in. overall, and thread upset end for ⅜-in. standard pipe.
One length ⅜x6-in. galvanized pipe. Thread both ends.
Four lengths ⅜ in. by 2-ft. galvanized pipe. Thread both ends.
Two lengths ⅜x3-in. galvanized pipe. Thread one end.
Eight ⅜-in. galvanized-iron sleeve couplings.
One ⅜-in. galvanized-iron tee.
Two 8-in. Cochran or Stillson pipe wrenches.
All pipe threads to be cut full standard depth, rubbed free from slivers and heavily greased.

The tee with the two 3-in. lengths of pipe forms a handle for turning. In use, the auger is shoved down without turning to the elevation from which a sample is desired, a few turns are made with a slight pressure on the stem and the auger withdrawn. The single worm auger specified has been found especially satisfactory in retaining samples, which may be secured with ease from muck, clay or sandy clay soils. By careful manipulation and some experience, sand samples may be secured from moderate depths; but thick strata of sand, especially where water is present, cannot be sampled satisfactorily with an auger. In hard formations it is of course necessary to bore down for the entire distance.

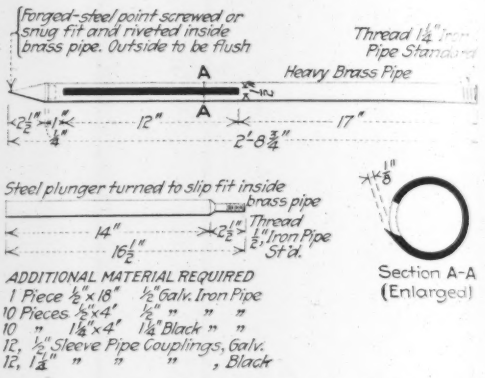
For convenience in transportation to points where only a moderate number of borings is to be made, an additional stem and handle are made of ¼-in. pipe and fittings, using a ¼x⅜-in. reducer at the auger and cutting the ¼-in. pipe into lengths for packing into a grip. The heavier pipe is recommended for ordinary use, especially where many snakes may be encountered. The cost of the single outfit with ⅜-in. pipe, wrenches, etc., will be about $5.

Special Sampler for Deeper Borings

In making deeper borings for investigating foundation conditions, a more elaborate device is employed. This is illustrated by the accompanying cut. In use, the steel plunger is screwed to the 18-in. length of ½-in. pipe and slipped to the bottom of the brass "core barrel." Brass pipe is used for taking the sample, as it runs true to bore and an accurate fit of plunger may be secured.

*Consulting Engineer, Hibernia Building, New Orleans, La.

The instrument is forced down into the ground and successive lengths of the 1¼-in. and ½-in. pipe added until the desired depth is reached, when the plunger is withdrawn far enough to insure clearing the slot cut in the core barrel. In soft material the suction resulting from a sudden withdrawal of the plunger will cause the barrel to fill to the top of the slot, but in harder material it is necessary to rotate the larger pipe by using a pipe wrench, the lip on the brass pipe shaving off a sample. Care should be exercised to see that the slot is fully



SHAW'S SPECIAL SOIL SAMPLER

covered by the plunger until ready to take a sample; otherwise the exact location from which the sample is taken will be in doubt.

If much work is to be done it will be found convenient to erect a staging from which the pipe may be handled. By providing a short length of 1¼-in. pipe with a driving head a moderate amount of driving may be done to pass through sand or other hard strata. Black iron pipe is specified for the outer casing as it is stronger than galvanized pipe and less likely to break off at the joints. Samples have been taken from a depth of 40 ft. with a device of this nature. This equipment may be secured at almost any well-stocked machine shop at a cost of $15 to $20.

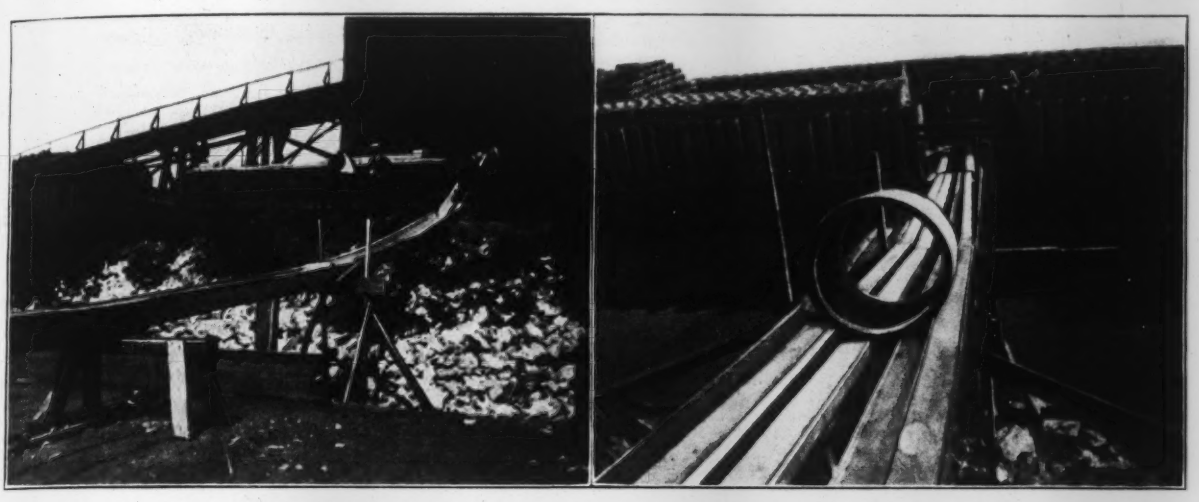
Unloading River Barges by a Series of Chutes

A series of chutes was employed recently to unload concrete drain tiles from barges along the Illinois bank of the Mississippi River. A mast was erected on the deck of the barge, and a chute extending to the bank was hoisted to an inclination which would allow the tiles to slide on the greased runners. Another mast was placed at the foot of the first chute, and another chute was hoisted high enough so that the tiles could slide to a point farther up the slope of the bank. At the foot of this second chute another mast and chute were placed, so that the tiles in the third slide reached the top of the bank. The chutes usually were placed about breast high to a man, so that a man could lift the tiles into the chutes and start them on their way up the bank. At each point of pause another man picked up the tiles and placed them on the next chute. To load the barges only one run of chutes was necessary. The illustrations show the method of loading.

Tiles were loaded on 90-ton barges by the Zeidler Concrete Pipe Co., of Muscatine, Iowa, and the barges

were towed down stream about 11 mi. from Muscatine to the unloading point, which was in Mercer County, Ill. After unloading, the tiles were transported inland several miles by wagon and placed along drainage ditches.

Extensive farm-drainage work is under way in this county on the lands of the Mueller Lumber Co., Zeigler Bros., and M. P. Bomke. Seventy-five miles of 6-in. to 22-in. tiles are being laid. The drainage system was laid out and is being constructed by the Central States Engineering Co., of Muscatine, of which C. H. Young is chief engineer.



TYPE OF SKIDWAY USED FOR HANDLING TILES; LOADING FROM CARS TO BARGE

A Retaining-Wall Failure That Was Not a Failure

By J. E. Smith*

An interesting little piece of emergency work was accomplished late in the summer of this year by Freeman & Brooks, contractors on the Illinois Building, Champaign, Ill., in restoring to an upright position a 17-in. brick wall of rectangular section which had been tipped over by earth pressure to a degree which to the layman looked like failure. Spectators of apparently much intelligence along other lines than engineering were heard discussing the wall "failure," and the conclusions arrived at would surely have been discouraging to the contractor had they reached his ear. Their unanimous verdict was that the wall was a total wreck and should be torn down and rebuilt.

The wall in question was not a part of the foundation wall of the building but was located a few feet outside of, and parallel to, the line of the building to serve as a retaining wall to carry the concrete sidewalk of the street and also to form the outer wall of an extension of the basement a few feet under the street. The plans called for buttress walls at intervals of about 20 ft., connecting with the side-wall columns of the building, but these had not been started at the time. The wall was 10½ ft. high, 120 ft. long, with returns at the ends extending to the line of the building, and weighed approximately 46 tons. It was set upon a concrete footing 25 in. wide, and the masonry consisted of common hard-burned brick recovered from the ruins of the old building which burned last spring on the site of the new building. The mortar used was of portland cement and sand, with proportions about 1 : 4.

Following the completion of the wall, the earth, consisting of yellow clay, was filled in back of the wall even with the top; but on account of its dryness and the expectation of soon connecting the wall to the main building with the buttress walls at the columns, sufficient precaution was not taken to provide against excessive earth pressure on the back of the wall. Unfortunately several days of heavy rainfall followed, and the backfill settled about 12 in., becoming practically a fluid. The consequent heavy pressure broke the bond between wall and footing and tipped the wall forward toward the building until it was 6° out of plumb, the top having moved about 14 in. A large crack developed at each end, running from the bottom corner near the return diagonally upward to the top, making an angle of approximately 26° with the footing—about a 2 to 1 slope. The portion between these cracks tipped forward as a single piece and remained perfectly intact, which was remarkable in view of the fact that the average length was 100 ft. and the weight approximately 38 tons. It indicated either a uniformly strong bond developing during the interval after the wall was completed, which was about two weeks, or a very uniform distribution of the earth pressure, acting practically as a perfect fluid, or both. The ends of the wall next to the return remained vertical and showed only minor cracks near the top.

The movement of the wall was checked by placing against its face five struts spaced about 20 ft. apart. The line of the center of gravity had not fallen outside of the base, so that when the backfill was removed, relieving the earth pressure, the wall settled back about one-third the way toward an upright position. The mud was then thoroughly washed from beneath the wall and a rich cement mortar flushed in. Five small hand jacks placed at the struts brought the leaning wall back to its upright position, still intact, in less than three hours' time. The diagonal cracks were grouted and pointed up and the back of the wall given a waterproof coating of asphalt. So far as strength and appearance were concerned the wall was as good as ever, and the cost was a small part of what it would have been if the wall had been rebuilt.

*805 Indiana Ave., Urbana, Ill.

Resurveying the Ohio Division of the B. & O. S. W. R.R.

By W. W. Gruber*

The following data were compiled during 1913-14 while the writer was employed by the Baltimore & Ohio Southwestern R.R. on a survey of the Ohio division, from Oakley to Athens, Ohio. This work was done with a twofold purpose in view—to furnish the real-estate department with a complete and uptodate set of right-of-way maps and to supply the maintenance-of-way department with revised operating maps.

To meet the requirements of both departments, it was necessary to locate all right-of-way and old land lines, also all yards, sidings, tracks, signals, bridges, buildings and other improvements on and adjacent to the company's property, or on that of industries or other property served by the railroad.

A complete detailed survey was necessary except for 9.6 mi. of track recently reconstructed. The chaining was all done on the right-hand rail of the eastbound main track, each station being marked with white lead on the outside of the ball of the rail and every tenth station painted over the ball and web and numbered. Curve deflections were taken on the center line at each station. Track centers were located by a rod of such length that when one end was placed against the web of the rail, the other end was on the center line. On turning points this rod was applied to both rails and a tack placed at the average point. Curves were run until well beyond the P.T., and the angle turned to the tangent.

To locate land and street lines, etc., where pluses were not required closer than about two or three tenths of a foot, the intersections with the center line were made by holding a plumb-bob over the gage of the rail, sighting over the string and moving until the string coincided with the intersecting line. After an intersection was made on both rails, the left-hand point was transferred to the right-hand rail, and the plus taken to the middle point between the marks. The angles were turned from the intersection with the rail on tangents, and on curves were turned from the intersection with the center line to a backsight at the farther of the adjacent points on the curve.

In many places original line fences had been removed. Here a careful search was made, and often corner stones, a line of old stubs of posts or post holes were found and located by plus and angle. If no better evidence than the general appearance of the ground was found to show the location of the line, it was located approximately, so noted, then checked with the old records and deeds by the draftsman.

No attempt was made to run out right-of-way lines, but all fences and buildings adjacent to the railroad property were located and existing encroachments determined from the maps. A very careful search was made for any property and center-line monuments, and many were found which proved to be very valuable in getting the right-of-way. Lines dividing right-of-way parcels that could not be established from the original deeds or some trace of them, and were not monumented, were plotted from deeds and old records, or were marked indeterminate on the maps.

Parallel sidings were located by offsets, and spurs not parallel by deflections. Buildings and other structures were tied in by pluses and right-angle offsets, if practicable, or by angles and distances from points on the center line. Right-of-way fences, creeks, roads, etc., were usually located by taking the distance at each fifth station, or closer, to a point in a line at right angles to the center line.

In towns the usual procedure was to establish the center line and locate intersecting street lines, then make a closed traverse with adjacent streets, the center line and the first street parallel to the track. Angles were turned three times and the traverse made to close within one minute. The streets and center line were roughly plotted to scale in a cross-section notebook and the details then filled in. Through yards and division points, spur tracks on which deflections were necessary usually served as base lines to tie in structures, etc.; otherwise random lines conveniently located were used.

As soon as practicable, 1,000-ft. markers—2-in. square cast-iron pins 3 ft. long, with the thousand number cast on the side—were set on the sod line opposite the 1,000-ft. points, so that the stationing would be maintained for future surveys.

New maps were plotted except for one section of 9.6 mi., where a set of reconstruction maps, on a scale of 1 in. = 100 ft., was traced. The curves on this section were traversed and new pluses taken so as to make the stationing conform to the new system. All maps were made on sheets 24 in. in width and from 10 to 14 ft. in length, as convenient, and were plotted to a scale of 1 in. = 200 ft., except through yards, terminals and towns, where a 100-ft. scale was used. Through some of the smaller villages the map was also made on the 200-ft. scale to avoid breaking the continuity, and in addition a small 100-ft. inset map was made to show details for use of the maintenance-of-way department.

Practically all information shown in the field notes, such as dimensions of buildings, bridge spans, clearances, etc., was put on the tracings, except deflections on curves and random lines. In addition to this, all dimensions given in deeds and the width of right-of-way were shown, and such explanatory notes regarding old land lines as necessary were made. The plotting was done on detail paper,

TABLE 1. COST DATA FOR NEW MAPS

Item	Survey	Drafting	Total
Actual work	$3,016.00	$1,043.00	$4,059.00
Actual work, per mile	20.93	7.24	28.17
Supervision	632.00	218.00	850.00
Supervision, per mile	4.39	1.51	5.90
Work and supervision	3,648.00	1,261.00	4,909.00
Work and supervision, per mile	25.32	8.75	34.07

TABLE 2. COST DATA FOR REVISING OLD MAPS

Item	Survey	Drafting	Total
Actual work	$80.00	$103.00	$183.00
Actual work, per mile	8.33	10.73	19.06

TABLE 3. FORM FOR SHOWING DEED REFERENCES ON MAPS; B. & O. S. W. R.R.

No.	Document	Date	Grantor	Grantee	Recorded Vol.	Recorded Page	Consideration	Section	Township	Co.	Remarks
1	War. deed	July 6, 1848	Jas. Smith	M. & C. R.R.	10	431	$500	33	Scioto	Ross	
2	Q. C. deed	May 7, 1848	G. F. Smith	B. & P. R.R.	12	231	100	31	Scioto	Ross	
3	Release	Sept. 1, 1849	S. T. Smith	M. & C. R.R.	G	492	$1 and cattle guards	1	Madison	Brown	
4	Condemnation	Sept. 23, 1849	A. K. Smith	M. & C. R.R.	Jdg., Bk. 4	361	$426	3	Madison	Brown	Com. Pleas Court No. 2, No. 4261, Sept., 1849

*Cincinnati, Ohio; Abstractor, Valuation Department, Cincinnati, Hamilton & Dayton Ry

without dimensions or lettering, and was not intended for filing.

In several instances where the alignment had been changed, considerable time was consumed in reproducing the original center line. In these instances the old, torn and dust-covered drawings, which we are so often tempted to consign to the waste basket, proved invaluable.

The length of main line and branches, exclusive of the 9.6 mi. previously mentioned, is 144.1 mi. The cost of making the survey, drafting and supervision of this portion is shown in Table 1; the cost of the resurvey and revising of maps for the 9.6 mi. is shown in Table 2.

On the 9.6 mi. the cost of drafting is higher than for the new maps. This is due to the fact that the maps were all on a 100-ft. scale and that all old and new right-of-way was shown, most of which was on curves and in irregular parcels.

The cost of fieldwork was $300 per month, of which $100 was for party expenses. The cost of drafting was $105 per month. The average rate of work for the field party of three men was 1 mi. in 17.1 hr. and for the draftsman 1 mi. in 14.6 hr. For the new map 25.7% of the cost is chargeable to drafting and 74.3% to the fieldwork. The total number of right-of-way conveyances was 804, or an average of 7+ per mi. On single track the average was 5 per mi., and on double track 9 per mi.

The 1,000-ft. markers were distributed by the section gang, then set by two section men under the supervision of a rodman, at the rate of about 25 per day. The markers were driven with a sledge, a block of wood being used to absorb the shock and prevent breaking them. Where 1,000-ft. points came on bridges, no markers were set.

The distribution of time for making maps averaged as follows: Plotting field notes, 33%; plotting deeds, 14%; tracing, 27%; lettering details, 19%; lettering deed data, 4%; caption, 3%.

Deed data were shown as in Table 3. The numbers in Column 1 were put on the map to designate the parcel of right-of-way covered by the corresponding deed, each number on the map and in the deed reference column being inclosed in a circle.

NOTES

Record Plans of State-Aid Highways in New Hampshire give all progress data usually kept in several separate files in other highway department offices. These plans are on a scale of 1 in. = 2,000 ft. and comprise a profile on a vertical scale of 1 in. = 100 ft. showing all elevations referred to a sea-level datum, a record strip for construction and maintenance data and a plan of the highway showing all cross-roads, railroad crossings, permanent station marks, location of gravel pits, quarries, crushers, etc. The plan does not show alignment, because few New Hampshire roads have ever been surveyed to obtain complete alignment data. Surveys have been made of short sections for the purpose of curve widening or road straightening, etc. There is no reason, however, why alignment should not be shown on a similar plan, except that the scale is rather small for convenient plotting. The notes in the middle of the strip give the length of the improved road with 1-mi. subdivisions, the type and date of the improvement and the name of the contractor or town (where the town made the improvement by day labor). All subsequent treatment of the road is shown in these same vertical divisions, as, for example, at the extreme right of the accompanying sample plan. Properly filed and indexed these plans give about as handy reference to all highway data as probably could be devised.

A Slope-Trimming Machine used for smoothing the embankment slopes for an oil-storage reservoir in California is described by E. D. Cole in the August "Proceedings" of the American Society of Civil Engineers, pp. 1327-1350, in the paper entitled "Concrete-Lined Oil-Storage Reservoirs in California: Construction Methods and Cost Data," presented to the society Sept. 15, 1915. The machine (Fig. 1) consists of a rectangular frame 11 ft. long and 6 ft. wide, built of 6-in. channels bolted together, carrying two cutting blades, which are ⅜x12-in. rolled-steel plates set at an inclination to the frame of 1 on 2½. The blades are also set at a slight angle longitudinally with each other. The cutting edges project 2 in. below the bottom of the frame. The trimmer is dragged back and forth on the slope until the ends of the frame ride on the tops of the guides. The cost of finishing the slope by this method was about one-half the cost of hand finishing. The slopes were both 1½ on 1 and 1 on 1. The crew consisted of seven men, including the hoist operator. Before using the slope-trimming machine men with mattocks and slope-level boards dug narrow trenches 1 ft. wide and true to grade from the top grade stake to the stake at the toe of the

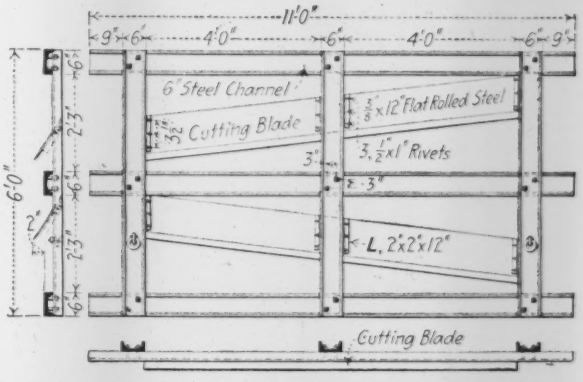
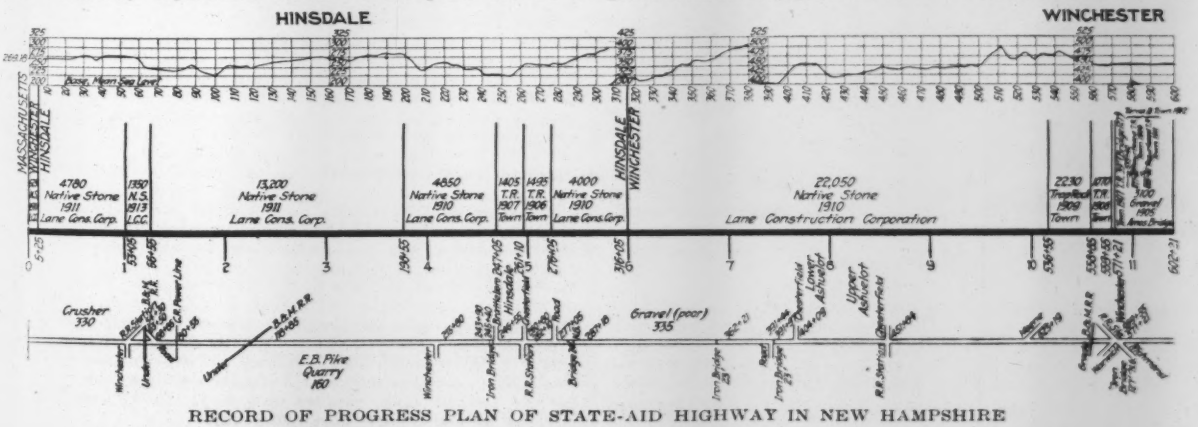


FIG. 1. DETAILS OF SLOPE-TRIMMING MACHINE Devised by E. D. Cole and C. O. Zeller



RECORD OF PROGRESS PLAN OF STATE-AID HIGHWAY IN NEW HAMPSHIRE

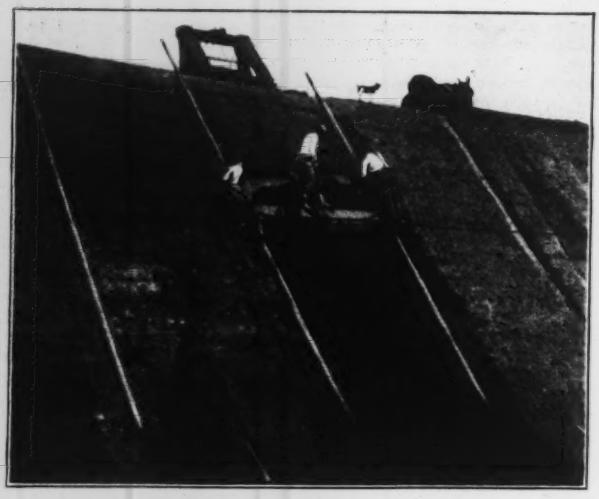
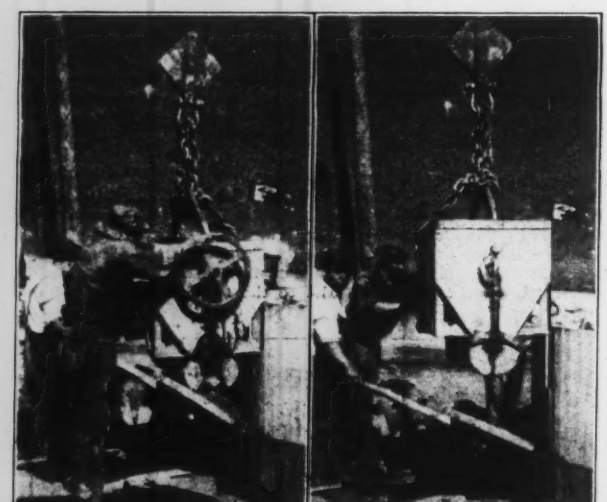


FIG. 2. SLOPE-TRIMMING MACHINE ON RESERVOIR EMBANKMENT

slope. These trenches were in approximately parallel lines (really radial). In the bottom of each trench were placed 2x4-in. timbers faced with strips of sheet steel, which formed the guides for the trimming machine. Before using the machine all excess material above the tops of the guides was scraped off with a specially made Mormon or buck scraper. The power for both the scraper and trimmer was furnished by a double-drum hoisting engine at the center of the reservoir. The back-haul line from the hoist was passed through a 12-in. snatch-block supported at the top of the slope by a portable wooden truss designed for that purpose, which was anchored against overturning by two heavy chains fastened to iron stakes.

Concreting an 8-In. Ring, 11 ft. in diameter, with a bottom-dumping bucket is the operation shown in the accompanying views. The work is for one of the shafts of a new waterworks tunnel under the Cuyahoga River at Cleveland, Ohio. Most of the concrete was poured through spouts, but after the shaft was practically completed it was decided to carry up the sides a few feet farther to keep out surface water. For concreting these sides a small portable batch mixer, a



CONCRETING AN 8-IN. RING WITH A BOTTOM-DUMPING BUCKET

derrick and a Doud bottom-dumping bucket were used. To use a bucket to fill an 8-in. ring required a little ingenuity. The inside form was made high enough to prevent the concrete falling in that direction, and a portable wooden deflector with a pair of handles was used under the bucket as shown. The superintendent of construction for the City of Cleveland is J. A. Vandevelt.

To Hasten the Setting of Concrete, calcium chloride may be incorporated in solution with the mixing water. The United States Bureau of Standards has been experimenting with the method and has found that the use of a 2% solution of calcium chloride in place of the mixing water will materially accelerate the hardening of the concrete. The acceleration varies somewhat with different cements. With some cements in 1:2:4 concrete it was found that the strength increased 100% in 24 and 48 hours. By microscopic examination it was found that when calcium chloride was used the tricalcium silicates and tricalcium aluminates were more completely hydrated and an appreciable amount of the dicalcium orthosilicates was hydrated, while practically none was hydrated in the normal concrete. It is intended to continue this investigation in order to determine, if possible, the ultimate value of calcium chloride when used in concrete. Its use will add about 12 to 15c. per cu.yd. to the cost of concrete. Calcium chloride should not be used in reinforced concrete if it will be at all exposed to electrolysis as the salt accelerates corrosion.

A Dragline Carried on Timber Pads is used for excavating trenches on three contracts of the Greater Winnipeg Water Supply. These dragline machines stand at the end of a trench and work backward, the bucket being dragged toward the machine and then swung out to the side to form the dump. The draglines are carried on 16x8-ft. pads of heavy timber and

DRAGLINE STANDING ON SOFT GROUND AND EXCAVATING TRENCH FOR THE GREATER WINNIPEG AQUEDUCT

are able to work successfully upon muskeg so soft as to be hardly able to bear the weight of a man.

To move forward, the machine picks up the pad nearest the end of the excavation and swings it around behind the machine, in line with the trench. Skids are then laid upon the extension of the pads, and upon these the machine pulls itself back by anchoring the bucket in the ground behind and pulling on the line. The skids, or rollers, which are of 6-in. pipe, are blocked after the machine is in position for excavating. Moves are made quickly, and the machine does its own grubbing for placing the pads. One of these draglines is shown in operation.

Electric Delivery Vehicles have been selected in preference to gasoline-driven machines by the department store of Meier & Frank Co., Portland, Ore., as the result of the studies and experience of A. N. Stanton, superintendent of deliveries. The company made its first trials in 1909, when it was found that the cost of delivering a package was 0.7c. cheaper by the electric than the gasoline car. The first electric car purchased was of 800-lb. capacity, and this was followed by three of 1,500-lb. capacity, one 1-ton and two 2-ton trucks. In 1911 four 1-ton cars were built especially for the company. One of the earliest records made by the first of the special cars was on a run of 14½ mi. with 157 stops in 195 min. In another run a distance of 37½ mi. with 340 stops in one day; later, 55 mi. with 740 stops were covered in one day. In 1912 four gasoline trucks were purchased and operated, but were later replaced by four 3,000-lb. electric cars equipped with nickel-iron batteries. Practically no difference was found between this type of battery and the lead cells as far as charging cost was concerned, but the nickel-iron battery maintained the original radius of mileage more uniformly than the lead. One great advantage cited by Mr. Stanton is the fewer number of motions required by the driver of an electric vehicle over that required for a gasoline car, the ratio being 5 to 12 for a stopping-and-starting cycle. This is considered to give the driver a better opportunity to bear his other responsibilities. The upkeep cost per mile was 3.62c. for gasoline cars and 2.57c. for the electric cars. Grades of 5, 9, 11, 15, 17 and 20% are covered by the electric cars every day.

Editorials

A Little-Known Earthquake

Earthquake phenomena are of much interest and importance to the engineer. In regions where earthquakes occur with some frequency it is recognized that in the construction of dams, buildings and other structures certain precautions should be taken that are not necessary elsewhere. The information available, however, as to the regions of the United States where earthquake movements may be expected is exceedingly meager. Over all the territory west of the Mississippi River the period of settlement has been too recent to make possible records of earth movements covering any considerable period. Further than this, the world at present relies chiefly on newspaper enterprise for information as to what is happening; and matters of scientific interest generally play a subordinate part in the newspaper scheme of things.

There is another reason why newspaper reports of earthquake phenomena are very incomplete sources of information. As is generally well known on the Pacific Coast, the San Francisco newspapers, ever since the great earthquake and conflagration of 1906, preserve absolute silence with respect to the earthquake trembles which frequently occur in that city and its vicinity. The governing motive is of course the same as that which governs so many otherwise inexplicable things on the Pacific Coast—to avoid doing anything which might unfavorably affect the price of real estate. This well-known policy of the San Francisco journals sets an example which has doubtless more or less influence in other quarters. One need not expect to find any very complete account of seismic movements in the far West printed in the local papers.

Elsewhere in this issue appears a paper written for *Engineering News* by Prof. H. P. Boardman, of the University of Nevada, describing an earthquake which occurred in northern Nevada in October last and which appears to have entirely escaped notice in the newspapers, although Professor Boardman's investigation indicates that it was quite as severe an earth movement as that which brought about the conflagration in San Francisco in 1906. The Nevada earthquake, however, occurred in a country so sparsely inhabited that the only structures affected were some railway water towers and a few buildings on ranches or in small hamlets.

There is some reason to believe that earth movements of magnitude are not very infrequent in certain parts of the United States. Dr. J. C. Branner, of Leland Stanford University, who has probably given more attention to the study of earthquake phenomena than any other American scientist, is authority for the statement that the earthquake in the Imperial Valley, of June 22, 1915, described in *Engineering News* of July 29, was probably at least as severe an earth movement as that at San Francisco in 1906.

It would be valuable information to engineers if a systematic investigation were made of earthquake movements of magnitude and if their location, extent and foci could be definitely ascertained and recorded. With the aid of such records it would be possible to locate definitely the fault lines in the earth's crust along which motion has occurred in recent times and is most likely to occur again.

To obtain the necessary information over the wide extent of territory to be covered, however, is a difficult matter. The United States Geological Survey would probably be the best organization to undertake it, but to secure the best results it would need the coöperation of some such widely extended organizations as the Post Office Department and the telegraph and telephone companies, assisted perhaps by such Federal Government bureaus as the Land Office and the Forestry Department, which have representatives located in the remote sections of the country out of reach of the mails and the telegraph.

If the Valve Should Fail

It is little short of criminal to subject a whole city to the danger of having its entire water-supply cut off through failure of an old valve, as is the case at Nashville, Tenn. The details are thus stated in a report made on the water-works of that city by James Cameron, public accountant, in coöperation with Barclay Parsons & Klapp, all of New York City:

> The supply from the reservoir to the city distribution system is now controlled by a single slide valve of a very old pattern. This 36-in. valve is of a plain slide type, controlled by a stem operated by a handwheel from the gate-house floor. The stem is attached by a single socket and cotter key to the valve rod, and this has been submerged and inaccessible for inspection except by a diver for years. We were informed that this valve is one of the original installation. A rusting or corroding of the cotter key might easily result in a dropping at any time of this valve disk into a closed position, cutting off the center city water-supply. This should be examined by a diver at once and arrangements made for making this valve stem more secure. A duplicate outlet main and modern water-works valve should be installed at an early date.

If dangers as great as this were confined to one city this Nashville incident might be overlooked. But scores if not hundreds of other cities are in as great or greater danger through failure to eliminate from their water-works some weak spot that might result in cutting off the whole water-supply.

Similar conditions exist also, without doubt, in connection with company-owned plants. At a large hydro-electric power plant in western Canada, recently visited by one of the editors of *Engineering News*, the normal water-supply is supplemented at times of low water by drawing from a lake on another watershed through a four-mile tunnel. Gates at the head of the tunnel control the discharge of water from the lake. These gates are in tandem, tight-closing slide gates above and Taintor gates below. At a time when only a week's surplus was left in the forebay reservoir, orders were sent to the headworks at the lake to open the gates. When this was attempted, however, it was found that at the high lake level then existing

the head against the slide gates was so great that they could not be moved.

The lake is located in a remote wilderness, 20 mi. from the nearest town. The chief engineer of the plant was routed out of bed at 2 a.m., and ran his motor car through rain and mud over a corduroy road to the headworks. It was found that the designer of the plant had omitted to install any bypass valve to admit water to the space between the upper and lower gates to relieve the pressure on the slide gates and enable them to be opened easily. Tools and men were hastily assembled and by working night and day for 70 hours, under great difficulties in a contracted space, enough water was admitted between the upper and lower gates to relieve the pressure on the former and permit their opening. It is needless to say that a permanent bypass valve was put in at the headworks at the first opportunity.

Similar stories of emergency work that might have been avoided by greater foresight in original construction or in maintenance could be multiplied indefinitely. Engineers who carry through such emergency work learn a lesson they are not apt to forget.

New Haven Blockade No Blow to Electric Traction

The complete blockade of the New York-New Haven electric zone of the New York, New Haven & Hartford R.R. during the severe storm of Dec. 13 and 14, news of which has spread all over the country, should not be regarded as a demonstration of an inherent difficulty in electric traction for trunk-line railroads. Nor is the New Haven blockade to be cited as a knockout blow to the overhead contact system compared with the third rail. It was apparently a direct result of stingy design—failure to provide adequate mechanical strength in electric circuits.

The tie-up was due simply and solely to the breaking of signal and feeder wires heavily incased with sleet and snow. No catenary bridges, masts or running wires went down. The signal and feeder wires did not break merely at one or two places, but the failures were literally innumerable along 60 mi. of line—indicating a general lack of strength for the loads imposed.

In striking comparison with this situation and the crippled condition of steam-operated lines in the East, the New York electric zone of the New York Central & Hudson River R.R. operated practically without interference through the storm. Comparison of the design on these two roads leads to the inevitable conclusion that the New Haven designers were constrained to be over-economical and that the company is now dearly paying for its parsimony, in loss of revenue and prestige.

Just one fact needs to be cited here to support that opinion: The New York Central's electric zone is traversed by a line of steel poles carrying transmission and signal circuits having functions fundamentally identical with those of the New Haven circuits that failed. The storm came from the northwest, and the Hudson River exposure was probably fully as severe as that along Long Island Sound. The New York Central did not lose a wire. Why? Probably because its signal-circuit spans were 150 ft. and the wires were No. 0 gage, compared with 300-ft. spans and No. 3 wire on the New Haven. The New York Central wires had half the span and twice the cross-sectional area.

It is apparent that the designers of the Central provided heavier insurance against breakdown than the New Haven engineers were permitted to employ. With the concentration of power supply which accompanies electric traction, there must be nothing less than complete protection against maximum conceivable onslaughts of weather—if such interruptions of traffic are to be prevented.

Data on Strength of Beams Are Inadequate

It is interesting news that the Secretary of Commerce and Labor requests an appropriation for providing a testing machine to make bending tests of large beams and girders. The Bureau of Standards has for some years looked forward to the provision of such a machine. Its present equipment, like that of other testing laboratories, is planned for tension and compression tests and can do only a limited range of small-sized work in bending. If the new machine is built, it will for the first time make possible the determination of the actual strength of large beams, plate girders, slabs, etc., as used daily in large quantities in every branch of construction work.

The calculations of the strength of girders are on their face so simple as to disguise the fact that a very slender basis of fact underlies these calculations. Plate girders with 100 to 200 sq.in. of sectional area in each flange have been built and are carrying railway trains, and the safety of these trains depends directly on the soundness of the calculations by which the flange area was proportioned. The calculations, however, contain a number of quite remarkable assumptions: That the entire area of the flange resists as a unit, that the flange is free from bending stresses and local irregularities, that the shearing service of the web plate is not seriously interfered with by other stresses, and so on. All of these assumptions introduce doubt as to what stresses exist in the girders; in other words, how safe it really is. Only by tests can this be determined—tests not necessarily on the largest structures that have been built, but on sizes approaching them near enough to give us confidence in the truth of our methods of analysis and proportioning.

The situation amply justifies the wish that the appropriation may go through and the machine be provided and put in service.

A point not to be lost sight of is that the design, size, etc., of this testing machine should be based on a thorough canvass of the range of service that it may be called upon to give. It is desirable that engineers in various branches of work should formulate their views as to the kind and size of bending tests necessary and submit these to the bureau in order to make it possible to plan soundly and wisely in this respect.

Overspecialization in the Engineering Schools

Engineering News is often obliged to reject articles offered for publication discussing at length problems in engineering education because of the urgent demands upon its space for articles dealing with current engineering works. The article by Professor Wilson, of the

University of Illinois, published elsewhere in this issue, however, presents with commendable brevity such a strong and convincing criticism of certain present-day tendencies in technical education that space had to be made for it.

It is true that to most of those who have given careful study to engineering education the argument made by Professor Wilson against overspecialization in technical education will not be new. It needs but a glance, however, at the courses of study laid down at most of the engineering colleges to see how far apart are the principles accepted by leading engineering educators and the actual practice of the schools.

It is too much the custom to pass the matter over lightly with the remark that the mental training to be acquired in the four-year course is the main thing after all and that the student will get about as much of this training in one study as in another. That is a statement that will not stand analysis. It is a fact that thousands of boys in our American universities today are being held down to laborious work on a vast mass of technical detail and drill that is narrowing rather than broadening in its educational effect; furthermore, there is being developed in the boys an aversion to any but their selected narrow field and a positive distaste for the so-called "cultural" studies.

There is, however, one argument made by those who defend the present specialization in the engineering schools which deserves some attention. It is said that the number of boys who are studying engineering in some form in the hundreds of schools that are teaching it is so enormous that only a very small percentage of those who graduate can ever hope to reach anything more than a mediocre position in professional work. The number of chief engineers, managers and superintendents needed is comparatively limited, while a hundred times as many men are required with detailed technical knowledge that will fit them for service as designers, computers, draftsmen, instrument men, testers, inspectors, etc. College courses in engineering, it is said, should therefore be planned to fit the needs of the rank and file in the profession rather than of the few who are to become its leaders.

There might have been something in this argument thirty or forty years ago when the scope of engineering work was so narrow that it was possible to give a man during a four years' college course some technical familiarity with most of the work that the average engineer is called upon to do in the field or in the office. The development and specialization of the engineering profession have changed all that. The rank and file of the profession is doing a hundred different things today that were not thought of twenty-five years ago. It is impossible to tell during a boy's college course what line of engineering work he may chance to drop into, if indeed he follows engineering work at all. Changes in economic conditions are constantly changing the tasks of the engineer. A generation ago the demand for engineers for railway location and construction had much to do with shaping the courses of study in technical schools, but the graduates of that day have nearly all had to turn to entirely different fields of work since.

There is indeed a demand for technically trained men from a great variety of industries, and of course many of those who voice this demand would like to have the colleges accomplish the impossible—furnish them competent and experienced experts in a special field of work as the result of a four-year course of study. But the boys trained in any such narrow specialty too often find to their cost that they have so limited a field in which to work and so limited a number of employers that promotion is wellnigh impossible.

Professor Wilson's paper is opportune in view of the current investigation of engineering educational methods which is being carried on by a joint committee of the national engineering societies in coöperation with the Carnegie Foundation for the Advancement of Teaching. *Engineering News* strongly commends his discussion to this organization.

Derailments the Chief Cause of Railway Accidents

The black spot in American railroad practice has long been the frequency of collisions and the heavy casualties resulting from them. The annual report of the Interstate Commerce Commission just issued makes it evident that the widespread extension of the "safety-first" movement in recent years and the general adoption of improved methods of operation, such as the block system, have materially reduced the number of collisions. It is exceedingly disquieting, however, to learn that while collisions have been decreasing, derailments have been increasing.

To quote actual figures, in 1902 there were 8,675 train accidents reported to the commission, of which 5,042 were collisions and 3,633 were derailments. Six years later, in 1908, the collisions had decreased and derailments had increased until their number was about equal.

In the year ending June 30, 1915, derailments outnumbered collisions almost two to one, the figures being 3,538 collisions and 6,849 derailments. Of 40 derailments which the commission investigated during the year, 11 were caused by bad track.

The commission, referring to the investigations of rail failures which have been made, says, "The remarkable increase in speed and weight of trains in recent years confirms the necessity for further investigation to determine with accuracy the stresses to which equipment and track are subjected under present service conditions in order to establish safe working limits for their use."

As many readers will recall, the American Railway Engineering Association undertook some time ago to carry out investigations of this very sort, but the work has gone slowly for lack of necessary funds to carry it through. The statistics of derailments above quoted certainly furnish a strong argument for completing this work at an early date.

It is pretty well understood by track engineers that the stresses in track as well as the resultant damage in the case of derailments increase very rapidly as the speed of trains increases. On one of the largest Western railway systems a rule has been in force for several years limiting the maximum speed of trains under any condition to 50 mi. per hr. We are informed by the chief engineer of the railway in question that the enforcement of this rule has not only had a material effect in decreasing the number of train accidents, but it has also materially reduced the labor and expense of track maintenance.

Letters to the Editor

Ownership of Water Services

Sir—I was interested in the editorial on "Ownership of Water Services," in *Engineering News* of Nov. 25, 1915. I think the principal objection that water companies have to taking over the ownership and maintenance of service connections between the street mains and the houses is that the companies do not wish to do anything not absolutely necessary that tends to make imperative an increase in the water rates. The companies recognize that no matter what the cost of the service, the consumers will invariably object to an increase in rates or to rates higher than those charged in some neighboring towns.

Probably due to the slogan of some well-meaning but misinformed enthusiasts for cleanliness, that water should be as free as air, a psychological condition has been created which makes the general public very loath to spend money for water, although they will readily pay relatively higher rates for gas and electricity, commodities much less essential to the welfare of the community than is water.

The water-works associations and perhaps the engineering journals of the world might do much toward educating the public to an acceptance of higher water rates as essential to improved water-works service.

PAUL HANSEN,
Acting Chief Engineer, Illinois State Board of Health.
Urbana, Ill., Nov. 30, 1915.

Patents on Reinforced Concrete

Sir—The writer has noted with much surprise your discussion of the decision of Judge Lewis in the Luten case in Denver in your issue of Dec. 2. Without entering into the merits of the particular suit, the obvious error of the reasoning which is put forward in the editorial excites comment if it is correctly understood by the writer.

With a given arrangement of steel the stresses are determined by mechanics, hence the principles of mechanics anticipate or negative patentable improvement in design. This position is indeed a novel one to the practical engineer. If by mechanics the stresses and consequent deflections are known in a reinforced-concrete design when the arrangement of steel is known, the writer would be glad to get acquainted with that new advanced kind of mechanics.

Invention may be defined as the discovery of means to produce a desired result, or an improvement in the art to which the invention pertains. A patent claim is a claim on a combination not necessarily of new things, but rather of old things which produce a useful result in a new and novel manner. Nearly all patented machines are made up of elements which are not novel in themselves, which are old and have been known and used for centuries. Thus the gear, shaft, pulley, bearing, frame, lever, etc., are old. When combined in a new and novel manner to produce a new result the practice of the Patent Office is to grant the discoverer of this combination a patent thereon after due proceedings are had.

Now as in the machine, so in the reinforced-concrete structure. The elements are old. Hammered iron rods were buried in puzzolan cement concrete at a date prior to the Christian era, so that the process of burying metal in concrete is a little too old to be patented, notwithstanding that two years ago a judge in the District Court decided that reinforced concrete, if it was patentable at all, was patentable as a process. He might as well have said that it was not patentable at all. (His decision was reversed by the First Circuit Court of Appeals.)

Now the combination and arrangement of the metal in a concrete structure may represent novelty. It may produce greater economy or greater stiffness with the same material than arrangements used earlier in the art. The mere fact that after such an arrangement is devised it may be possible to discover what the stresses are under load by the principles of mechanics in no wise negatives novelty in the arrangement, because under the principles of mechanics the arrangement has to be made first before we can tell anything about the bending stresses in the structure. Otherwise the principle of rigidities, the law of least work, etc., would not apply. Now as the arrangement has to be made before the principles of mechanics can be applied and the arrangement is the means for the discovery of that for which the patent is granted, it would seem that there was radical inconsistency in the editorial referred to.

It seems to the writer that before our patent system may be considered as fulfilling its intended object, there is needed a patent court of appeals of technical experts. The need of such a court has been long recognized by the Bar Association, but its repeated effort to secure such a court has so far been unavailing. Public opinion may perhaps bring about that which the commendable efforts of the Bar Association have thus far failed to accomplish.

F. A. CAMP.
600 Jewelers Exchange, Minneapolis, Minn.,
Dec. 7, 1915.

Sir—In your issue of Dec. 2 you state that the decision of Judge Lewis lays down the principle that the arrangement of the metal parts of a structure to resist the stresses set up involves merely mechanical design and not invention. Now this is a principle applicable equally to articulated structures and to reinforced concrete.

A truss, for example, is a combination of triangular frames. But triangular frames have been used from time immemorial, and hence on this principle there could be nothing patentable in any truss. But the Patent Office of the United States long ago issued patents to Fink, Bollman, Howe, Burr, Post and many others for the arrangement of systems of triangulation in trusses, because these inventors had secured certain tangible advantages, structural and economic, in single-span trusses

by special arrangements and combinations of triangles. In case of cantilever and multiple-span bridges the number of possible arrangements of parts has no limit. Some of these combinations show inventive genius in high degree, so much so that the possible span of bridges has been increased three times in the course of the last fifty years, and this has by no means been accomplished by the "accrued knowledge of the profession."

The patent offices of the whole world are still granting such patents, and this just as much in Germany where "a new technical effect" is required as elsewhere.

If we are going to take the position that we have the principles of mechanics with us and anything that can be done in the structural line, since it is amenable to analysis by those principles, can be no possible improvement, then the object of the patent system by which it seeks to promote progress in science and the useful arts is defeated so far as most engineering is concerned. We should then confine patents to pioneer, or basic, inventions and mostly reject those for mere improvements; and that seems to be what is practically advocated in this editorial. Probably no one would have the hardihood to deny that the Wright brothers made a real invention in their flying machine, which consisted essentially in wings, steering apparatus and propeller. Darius Green excited the risibles of the whole past generation by proposing to fly with wings, and yet the Wright brothers did that very thing; and though before them Maxim and Langley had also done this imperfectly, the wonderful improvement made by the Wright brothers in working out the practical details and successfully flying was real invention, was it not? They made the improvements that made all the difference between failure and success in flying. What they did constituted a real advance in the art of the very kind that it is the intent of the patent laws to foster and protect.

Your editorial covers a similar case. Francois Coignet long ago described the reinforcement in concrete as "a metallic framework linked or arranged so as to strengthen the same." But that did not explain how it would be possible to make a successful reinforced-concrete floor slab that would imitate mechanically the action of a homogeneous flat plate such as steel. That could not be successfully accomplished by introducing the reinforcement in any way you might please, any more than flying could occur in case wings are by chance used. The first man who proposed thin slabs of concrete is so well known to the engineering profession that I do not need to mention his name. His proposal excited ridicule almost as universal as that of Darius Green, although he did not have the good fortune to have his immortality insured by putting his name in a poem. He not only proposed such a slab, but he built it as well, and thousands like it. It was as great a success in this field as the aëroplane in flying, and his success was scored against the adverse opinion of the entire engineering profession. And now if I understand your position, neither the Wrights nor he should have any patent protection.

I am not informed and therefore cannot say whether or no the alleged improvements considered by Judge Lewis are such as deserve protection, but I am saying that in my opinion the position taken in this editorial unduly minimizes the field of effort of inventors.

Taking the broad ground that reinforcement consists merely in burying metal in the concrete, the editorial position would evidently be to put metal where the greatest stresses are. But how will you find out where the greatest unit stress occurs or where the greatest stresses to be borne are to be found before the arrangement of the metal in the structure is determined upon? To do that is impossible, because this is what is called an indeterminate structure or one in which the stresses are determined by the relative rigidity of the parts.

The arrangement then is the thing that comes first before the principles of mechanics can be applied, and a patent is granted for any arrangement of parts in a novel and advantageous manner. It is evident that some arrangements must be superior to others, and so the position taken in the editorial is manifestly incorrect.

We may be ready to admit that the engineer would be better off without the patent system than he is with it so long as the Patent Office continues to grant patents on one theory and the courts continue to construe them as to validity and infringement upon an entirely different and contradictory theory. But it would seem to be the part of the editor of an engineering periodical to uphold the just claims of the men of this profession for due recognition and appreciation, men who are applying the materials and forces that they direct with the highest inventive genius, as against judicial discussions that are based on the most crass ignorance of the simplest principles of mechanics. H. T. EDDY.

916 S. E. Sixth St., Minneapolis, Dec. 10, 1915.

[Perhaps the best answer that can be made to the arguments presented in the foregoing two letters is to refer our correspondents to the opinion of the United States Supreme Court presented on page 1138 of our issue of Dec. 9. The Supreme Court there declares that "it was never the object of the patent laws to grant a monopoly for every trifling device which would naturally and spontaneously occur to any skilled mechanic or operator in the ordinary progress of manufacture."

In the editorial criticized we did not say that there can be or has been no invention in the field of reinforced concrete. What we did emphasize is that the ordinary placing of reinforcement in position to take stresses, such as is within the ability of any competent engineer experienced in reinforced-concrete design, is not invention, and patents based merely on particular arrangements of reinforcement ought not to be sustained unless it can be shown that the making of that particular arrangement involved invention.

Even though a man may be the first to use and to spread upon the patent records a particular way of placing reinforcing metal, he is not entitled to a monopoly of that particular arrangement unless he can show that his arrangement was a real step forward in the art.

And there is another point which deserves attention in this connection. The steady advance in technical knowledge brings within the field of the ordinary designer work which at an earlier period might rightly have been held to be invention.

The patents issued more than a half century ago to Fink and Bollman and Post and others, cited by Dr. Eddy, illustrate this admirably. When those patents were issued, little was known by practical bridge builders of the stresses in structures, and the forms of truss

referred to were real inventions—valuable contributions to the art. But with the advanced knowledge of bridge design current today, such particular arrangements of trussing could be made by any competent designer to suit the local conditions, and any monopoly of any such special arrangement would be justly opposed on the ground that no invention was involved in its creation.

Patents in the chemical field furnish an equally good illustration. Patents were issued many years ago for chemical compositions that today would be made in the ordinary routine work of any well-equipped chemical laboratory.

The position of the engineering profession almost without exception is that the designing engineer should not be obstructed in his regular routine work by patents issued to some other designer merely because the latter has devised some particular arrangement of parts, without making any real advancement in the art such as justifies the Government in its grant of a monopoly.—Editor.]

Outlet Boxes for Electrical Conduits in Concrete

Sir—One feature of concrete construction that is seldom given the attention it deserves is the proper placing of electrical conduits and outlet boxes in concrete floors. The men engaged in the mechanical trades involved in building construction seem to be imbued with the idea that reinforcement is simply used as a void filler and otherwise performs no useful function. For this reason the "all-important" reinforcement is regarded as a matter of secondary importance in the effort to make the work of other trades as easy of execution as possible.

Architects and engineers have given their stamp of approval to such conditions by an ominous silence, broken but seldom by some "overzealous young upstart" treading rough shod on the toes of the contractors who raise havoc with an otherwise excellent design by the methods they pursue in executing their portion of the work. Without question this condition is brought about by lack of knowledge on the part of the designer regarding seemingly small details, and the worked-to-death practice of "passing the buck" to the man who does the actual work.

In the past, designers of structures, especially buildings, have been too ready to take all the credit for the finished product of a half-baked design, elaborated upon and completed by the contractor with the stereotyped approval of the designer. This approval, with its usual limitations, means absolutely nothing in so far as the contractor is concerned, but always relieves the designer of responsibility. Until men are willing to make a complete design and assume the responsibility for it, much unsatisfactory work will result, and the designer, although he may have a loophole for immediate escape, will sooner or later be held in disrepute by contractors and owners with whom he has had dealings.

Specifications or plans as a rule give the information regarding the proper location of reinforcement, but fail to specify definitely the type of electric outlet box that will allow the placing of electric conduit without interfering with the reinforcement. As a result the contractor bases his estimate on the usual low box, it being the cheapest, and in executing the job insists on using that type. This practice in general plays havoc with the reinforcing, for the conduits, unless goose-necked at each outlet, lie in just about the same plane as the reinforcement.

This situation can be remedied very easily by the use of the high-outlet box 3 in. in height with the conduit entrance 1¾ in. clear above the bottom. The plane of the electrical conduits is thus raised clear of the reinforcement zone as a general rule, and this eliminates the trouble created by the electricians moving and bending reinforcing bars to make way for conduit connections with outlet boxes.

Some electricians are now using the high-outlet box almost exclusively, for they have found it much more satisfactory. The conduits can in fact be installed more cheaply than if low boxes are used, involving the moving and rearrangement of reinforcement, or the goose-necking of conduit to enter the outlet box. The fact to be emphasized, however, is that it is the duty of the architect and engineer to his client to specify beyond a doubt the type of box to be used. Then he can with impunity specify just where the reinforcement is to be in the finished work, and be reasonably sure that the specifications will be carried out.

A. M. Wolf,
Principal Assistant Engineer, Condron Co.
Chicago, Ill., Dec. 13, 1915.

Eccentric Loading Problems

Sir—In the article of R. Fleming, "Is a Part Stronger Than the Whole?" and the editorial comment thereon, Nov. 25, 1915, I think one point is not emphasized. It is not the dimensions of the piece but rather the type of loading and the character of the resulting strains that govern the strength of the body. Thus an axial load will produce bending merely as a secondary stress, while an eccentric load will produce bending as a primary stress, and a load producing bending is the most inefficient type of loading, since the stress in merely one plane determines the section of the entire member. It is then easily grasped that changing the dimension of a piece so as to alter the type of loading over the enlarged member will so alter the strains as to lessen the resisting strength of the body, as in the classic case of torsion developed by Saint-Venant it is shown that sharp corners produce infinite shears at the edge and hence should be rounded.

I do not agree with the editorial comment on Emerson's paradox. The existence of a crack is not a very serious matter. We would not punch metals if it were, since fine hairlike cracks are often started there. I think the objection to a crack is its appearance more than anything else, that is, of course, assuming that it is due to local excess of strain only. Likewise in the shipping and hauling of steel local injuries occur which we let pass.

G. Paaswell.
2726 Creston Ave., New York, N. Y., Nov. 26, 1915.

Sir—In your editorial comment on an able article entitled "Is a Part Stronger Than the Whole?" by R. Fleming in the issue of Nov. 25, 1915, your concluding paragraph contains the statement, "Common-sense is called for in dealing with problems in eccentric stress." The writer of this letter (who happens to be the engineer referred to in Case 3 of Mr. Fleming's article) thinks this is the crux of the whole subject.

There is a tendency in some quarters to stick slavishly to formulas. It is a curious fact that no one is more narrow and strict in the use of a formula than the man who has not the slightest idea how the latter was evolved. There are few formulas used in structural engineering which are not more or less empirical. There are very few formulas in which the conditions assumed in the mathematical analysis are realized in the working conditions. There are a large number of column formulas in use, but surely they cannot all be right under all circumstances. At best they are but imperfect expressions of the truth, and should be used with this knowledge.

The writer was once made to change a strut by a New York Building Department examiner because it was 130 radii of gyration in length. It carried but one-fifteenth of the allowable load, but this made no difference in the eyes of the examiner, who simply pointed to the code, which specified not over 120 radii. So I had to change the design, although it had already been erected.

There are two general methods of figuring wind bracing for tall buildings. I have seen advocates of one method look with absolute contempt on an engineer who used the other method, and vice versa, yet the facts are that in the analyses of both methods there are assumptions made which are contrary to actual working conditions.

We have seen how it is apparently possible to prove by algebra that 2 equals 1. This ought not to weaken our faith in algebra, but merely show us that sophistry can creep into any form of logic.

We use formulas for eccentricity as well as anything else because they are the best tools we have to work with. Every result, however, should be examined in a broad way to see that it is not obviously absurd, as knocking out a superfluous rivet would be. In other words, the rule of reason applies to formulas as well as to other things, and Mr. Fleming's article brings this home very aptly.

DAVID GUTMAN.

345 Bedford Ave., Mt. Vernon, N. Y., Dec. 7, 1915.

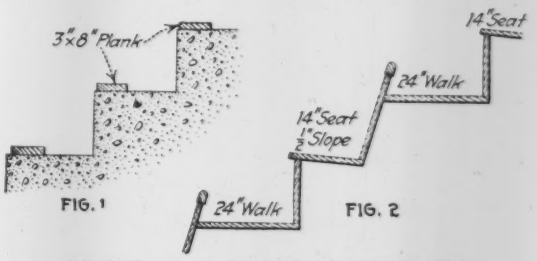
Seats for Grandstands and Railway Station Signs

Sir—As a number of large grandstands, stadium bowls, etc., are being built nowadays, a few remarks on the design from the point of view of the seat occupant may be of interest. It seems to me that in many cases his comfort has not been properly considered.

The writer recently sat for what seemed an eternity in a famous stadium having places for 30,000. The seats—if they can be called such—are built as shown in Fig. 1, the sitter having to rest on the 3x8-in. plank on the edge of the concrete step. There is no support for his back, and he is subject to the kicks of his neighbor behind him.

In the Amphidrome at Houghton, Mich., designed by the writer, the amphitheater seats are arranged as shown in Fig. 2. With this arrangement people can walk to their seats without trouble, and do not kick the people in front either in walking or when seated. This seating scheme is cheap and easily constructed. It seats a maximum number in a given space and can be adapted to any slope.

The insufficiency of station signs is a well-known weak point of our railways. The occasional visitor who takes the subway in New York is pleased to find that the stations have their names frequently and prominently displayed in numerous places on walls and columns. It has often occurred to the writer, when traveling even on our best railways, that a similar liberal use of signs for station names would add much to the convenience and pleasure of the passengers. Ordinarily a passenger in the car cannot see the name, except by chance or by much



DESIGN OF SEATS FOR GRANDSTANDS

neck stretching. Signs placed on both sides of the track and about 8 ft. from the ground, at both ends of the station, and so arranged that they can be read from any car on a long train, would be a boon to the traveler. The cost of installation and maintenance would be small as compared with the advantage.

J. F. JACKSON,
Wisconsin Bridge and Iron Co.

Milwaukee, Wis., Nov. 26, 1915.

Force Needed to Man Coast Fortifications in War

Sir—Apropos of the present discussion of military preparedness for the United States and showing an appreciation of its lack before it was so generally recognized is a word spoken over 10 yr. ago by Maj.-Gen. George W. Goethals, U. S. A., Governor of the Canal Zone, in his paper on "Fortifications" before the International Engineering Congress, 1904:

> At present the greatest difficulty is in the proper care of the guns already mounted. The Coast Artillery branch of the service, to which this belongs, is too small in numbers to man the guns now available, and the greatest danger now confronting the United States arises from this deficiency of properly trained men to fight the guns. At the outbreak of war a fleet could be off any important harbor within a few days, and long before it would be possible to organize the necessary volunteer force to properly man the guns; and even were this possible they would be ignorant of the technical knowledge now needed for the proper handling of the armament. This is a matter, however, which devolves upon Congress to rectify, and what steps will be taken to overcome this danger remains to be seen.

CALEB MILLS SAVILLE.

Hartford, Conn., Dec. 17, 1915.

[Things appear to have gone from bad to worse. Brig.-Gen. E. M. Weaver, Chief of Coast Artillery, in his annual report made public on Dec. 18 declares that we have not half enough troops to man the coast defences already built. The minimum force required is 1,942 officers and 47,176 men. Congress in 1908 adopted the policy of manning half the fortifications with regular troops and half with state militia. This policy has been a failure. The states have not furnished the men required by over 10,000, and the manning of fortifications in United States possessions overseas has left the army with only half the men and officers necessary to furnish its quota for manning fortifications on the coast of the United States.—Editor.]

Better Highway Specifications for Clearing and Grubbing

By F. W. Harris*

The following clauses are the usual highway specification for grubbing:

All stumps, roots, logs and other obstructions shall be grubbed out and removed from all places where embankments occur less than 3 ft. in height; also where excavations occur less than 3 ft. in depth, and from such other places as the engineer may direct.

All material so grubbed out shall be destroyed in the manner specified.

Grubbing shall be paid for by the acre or fraction of an acre. The area within the limits of the slope stakes, whenever grubbing shall have been done thereon by the contractor, shall be estimated only upon cuts up to 3 ft. in depth, and under embankments of 3 ft. or less in height, and upon uniform ditches wherever the engineer may direct.

This is the old railroad specification. It answered the railroad purpose well enough, for grubbing is but a detail in that class of work, owing to the heavy cuts and fills and the much narrower width of roadbed. It is only with the wide roadways and "scratch work" of roadbuilding that grubbing comes to the front as an important factor.

Grubbing has been estimated and paid for in at least four different ways—by lump sum, station, acreage, and square rod. All these methods are founded on approximate estimates. The lump sum was the easiest way adopted on small jobs where the contractor was in a position to make a fairly close estimate. Grubbing by the station was one way of payment used by the railroads where the cut and fill was under 3 ft. By the present system grubbing is paid for by the acre or fraction thereof.

Interpretation of Grubbing

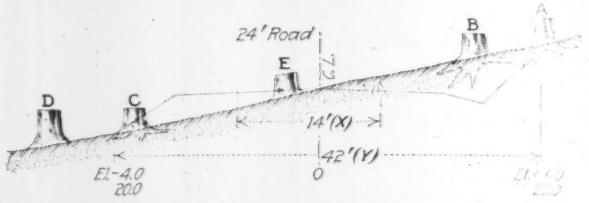
Such a clause has been interpreted in two different ways: One way is shown on the accompanying sketch as *X*, which gives a measurement of 14 ft. This method is close and very unfair. Others use a full width between the slope stakes, shown as *Y*. This gives a measurement of 42 ft., which is more fair and liberal for the following reason: Frequently there is a stump on the slope line (stump *A*) which the engineer wants removed for the sake of appearance. The same reason will apply for grubbing out the stump *C*. Also in both cases the stumps are within the 3-ft. limit. Even using the *Y* method of computing acreage, in nine cases out of ten the grubbing will be done at a loss to the contractor.

The present system of estimating the cost of grubbing for highways results in almost endless confusion and wild guessing, both on the part of the engineer in his estimate and the contractor in bidding. On one large highway contract involving the construction of 25 mi. of mountain road, bids on grubbing ranged from $100 to $300 per acre. The $100 man did not have the least idea of what he was doing. The $300 man figured a profit on the grubbing. In this case $200 was about right, as the grubbing was heavy and in addition to this there was a long and expensive haul to get powder.

The acreage of grubbing in the present estimates of quantity shows only the amount of grubbing that comes within the specification, and not what the contractor will actually be required to do. The engineer does not know the actual amount that the contractor will have to do; neither does the contractor, hence we have wildcat bidding on grubbing and no cost data on the subject that are worth a moment's consideration.

To remedy this condition the contractor should receive payment for every stump removed, regardless of the depth of cut or height of fill. He is entitled to be paid for grubbing stump *B*, as much as for grubbing stump *E*. The idea that stump *B* will cave in with the excavation is a fallacy, as this course is never adopted on construction work, for when a contractor is organized to shovel earth he does not want to break into the scheme to handle stumps.

The system of paying for grubbing by acreage must be abandoned and the stumps graded according to size. A convenient and practicable grading of sizes runs from 6 to 12 in., 12 to 24 in., 24 to 36 in., and above 36 in. No grubbing should be paid for on anything smaller than 6 in. Stumps from 6 to 24 in. should be measured 1 ft.



ROAD CROSS-SECTION, SHOWING HOW GRUBBING SPECIFICATION MAY BE INTERPRETED

from the ground. Stumps over 24 in. should be measured at the butt log. It would be impossible to measure large redwood, cypress and cedar stumps "breast high."

In the schedule of quantities submitted to contractors the stumps would be listed like the following:

100— 6 to 12 in.
125—12 to 24 in.
150—24 to 36 in.
200—above 36 in.

The contractor would then know just exactly what he has to bid on and what he has to move. He will be paid for every stump handled. It would be but a short time before grubbing would be standardized in price according to different localities, which would result in closer estimates of final cost.

There is another feature of grading stumps which makes it a valuable aid in making preliminary estimates, especially for those to be let on a lump-sum basis. The majority of engineers refuse to allow waste in any quantity to show on the profiles. This results in too close a theoretical balance, as the percentage of shrinkage is nearly always underestimated. Consequently the excavations will not make the embankments. A sag has to be put in the fill, or if earth is borrowed there is a bill of "extras" which makes the lump-sum bid almost useless.

Estimating Shrinkage

The method of obtaining an estimate of shrinkage in a timber country is as follows: Plot a trial grade line on the profile, seeing that the quantities balance reasonably close. The excavation should exceed embankment at least 10%. The profile will give the center cut and fill, and an experienced man can stand on the center line and estimate where the slopes will intersect the ground line.

The stumps in each station should be noted and recorded according to sizes and kinds of stump, also the formation of soil, whether rock, gravel or swamp. It is essential to note the kind of stumps, as some stumps will blow out much easier than others. For instance, a 4-ft. fir stump will leave a smaller hole than a 4-ft. cedar

*Renton, Wash.

stumps. This should be borne in mind merely as it would be a useless refinement to grade the loss of excavation by the kind of stump shot out. In the office the stumps should be listed according to cuts and fills.

The following table will apply on the Pacific coast for computing loss of excavation by blowing out stumps. Fir, cedar, spruce, hemlock are averaged in the table.

6 to 12 in.	1 cu.yd. each
12 to 24 in.	3 cu.yd. each
24 to 36 in.	5 cu.yd. each
Above 36 in.	10 cu.yd. each

In swamps where the growth is spruce, hemlock, cedar, maple, 50% should be added to these quantities, as it requires more dynamite to lift a stump of given size, owing to the decreased resistance of the swamp soils. To get shrinkage, say between Sta. 20 and 30, this would average a 4-ft. cut on the center line for the entire distance. Assuming the record shows the soil to be clay and hardpan, the list of stumps for this section would total 65, divided as follows:

6 to 12 in.	20	20 cu.yd.
12 to 24 in.	20	60 cu.yd.
24 to 36 in.	20	100 cu.yd.
Above 36 in.	5	50 cu.yd.
	65	230 cu.yd.

In this cut the grade line would have to be lower to give the additional 230 cu.yd. lost in blasting. As the same condition, however, is assumed to exist in the adjacent fill, the grade line will give a correct balance.

The grubbing clause should be revised to include the following:

All stumps and roots on the right-of-way to be grubbed will be paid for according to the list of sizes shown on the schedule of quantities. Stumps 6 to 24 in. will be measured 4 ft. above the ground, stumps over 24 in. diameter will be measued at the butt log or on top of stump.

Progress of Federal Railway-Valuation Work

The annual report of the Interstate Commerce Commission just submitted to Congress summarizes the progress made thus far with the valuation of the railways of the United States. On Jan. 1, 1916, field parties will have completed the surveys upon nearly 50,000 mi. of railway. The total mileage of railway in the United States being approximately 250,000 mi., there will be left on Jan. 1 about 200,000 mi. still to cover, and it is believed that this work can be completed in the next four years. The basis of this estimate is as follows: A year ago there were eight field parties engaged on roadway and track measurement in each of the five valuation districts into which the country is divided. They were covering from 1,500 to 1,700 mi. per month. In the early part of the present year the field parties were increased from eight to twelve, and since June 1 twelve field parties have been continuously at work in each district. Their average total progress from June to October inclusive has been a little over 4,000 mi. per month, or 66 mi. per month for each party. It is believed that with this number of parties continuously at work in each district about 45,000 to 50,000 mi. per annum can be covered. The commission thinks it doubtful, however, whether with the present organization this rate of progress can be materially exceeded.

Besides the field parties handling roadway, track, bridgework, etc., special parties have been organized for appraising bridges, buildings, signal apparatus and other equipment requiring special expert knowledge. This department of the field force, while behind with its work some time ago, has now advanced so that it is keeping pace with the parties engaged on the road surveys.

Another division of the field force is engaged in the appraisal of railway lands and rights-of-way. This division was organized later than the field parties engaged on roadway measurements and has not yet equaled the rate of progress made by them. In the months of August, September and October the average monthly progress of the land-appraisal forces was about 2,500 mi. per month. This lower progress has been partly due to inability to expand the force, since it has been found difficult to obtain suitable land appraisers through the civil-service examinations. New examinations have been held, however, and new lists of eligibles obtained from which additional appraisers will be appointed. With this enlarged force it is expected to bring the rate of progress in the land division up to that in the roadway division.

In the telephone and telegraph division five field parties are now at work and are covering a total pole-line mileage of about 6,000 mi. per month. The progress of work has been delayed by the lack of information that the telegraph companies should furnish. It has been found that neither the Western Union nor the Postal company has information as to the location of the greater part of its lines.

The commission indicates that it has not yet reached a decision as to the prices which it will apply in making the valuation after the quantities are determined. Tentative prices have been applied on the roads where the initial valuation has been made, but the commission states that it has not yet made its decision as to the final prices. It is collecting a great mass of information as to market prices, obtained from catalogs, quotations, correspondence and personal investigations. In addition statements have been obtained from the railways themselves as to the prices actually paid, and these reports have been checked by examination of the railways' records by the commission's own accountants. As to what additions should be made to the quantities and prices, the commission says:

It seems to be universally conceded that in addition to the amount obtained by the application of unit prices to the quantities shown by the inventory, certain additions commonly known as overhead charges must be made. These items are of significance and no opinion should be expressed upon them without the fullest possible information. . . . The commission has believed that it was wise to defer the application of prices and the final statement in dollars of the cost of reproduction new and the cost of reproduction new less depreciation until such information was available as would permit the formation of a reliable opinion.

The valuation act as passed by Congress required the commission to ascertain the original cost of each piece of property owned by the railways. The commission says that experience has demonstrated the impossibility of carrying out this requirement of the act. The best that can be done is to obtain the records of original cost where they are still in existence. In many cases improvements and additions to railways have been charged as part of the operating expenses. In other cases capital has been drawn upon to pay operating expenses. The commission states, however, that, broadly speaking, it can usually be determined how much money has gone into the railroads.

Effect of Iron and Calcium on Concrete Sand

By Thorndike Saville*

In conducting an investigation of the mortar-making properties of certain sands and gravels from several localities in New Hampshire and Vermont,[1] some peculiarities in the results of the tests marked two of the sands as having points of particular interest. The tests were conducted, with a few modifications and additions, after the procedure of the laboratories of Westinghouse Church Kerr & Co., as explained by Cloyd M. Chapman in *Engineering News*, Feb. 5 and Mar. 12, 1914.

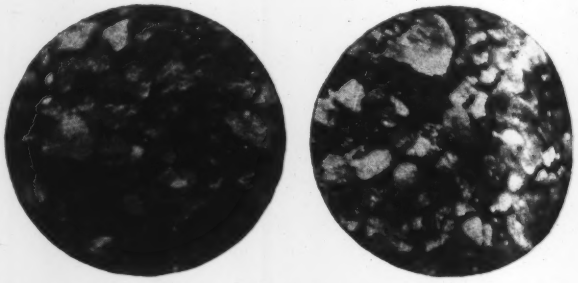
The ratios of the tensile strengths of 1:3 mortars made with five of the sands tested compared to the strengths of 1:3 mortars of standard Ottawa sand made at the same time are given in the table. Some of the tests with standard sand fell below minimum specification, due in large measure to the cement used. The relative strengths of mortars of the different sands when compared with standard sand made at the same time and under the same conditions were affected little. This was shown by making tests with the same sands in a few instances with a different cement, the tests showing greater strength, but the ratio to standard sand being about the same. This article does not purport to indicate what the proper results of tests, tensile or otherwise, ought to be. It presents merely the effects of certain impurities in sands upon their relative mortar-making qualities.

RESULTS OF TENSILE TESTS, RATIO THIS SAND TO OTTAWA

Sample	Occurrence	Impurity	3 Days, %	7 Days, %	28 Days, %
21	Concord	....	36	34	47.8
40	Portsmouth	Fe_2O_3	58	71	82.8
22	Pompanusuc	$CaCO_3$	160	123	188.0
35	Pompanusuc	$CaCO_3$	135	130	142.0
28	River	....	158	110	142.0

The sand from Portsmouth has the same uniformity coefficient, the same effective size and the same general appearance as the sand from Concord. Both are fine and even in texture, and a weak mortar would be expected. The Portsmouth sand (No. 40), however, tests well, while that from Concord (No. 21) tests low. Microscopic examination showed numerous red particles in the Portsmouth sand, which when tested gave a strong reaction for iron. They are probably of the nature of bog iron ore (limonite = $2\ Fe_2O_3 + 3\ H_2O$). This ingredient in the sand causes the mortar to set very slowly and to attain a much greater ultimate strength than it otherwise would, making of a naturally poor sand one of fair strength. The mode of occurrence of this sand the writer has been unable to ascertain, and hence the large amount of iron in it is unaccounted for.

The sands from the Pompanusuc (Vermont) region (Nos. 22 and 35), which contain a high percentage of calcium carbonate ($CaCO_3$) cement, are naturally of good quality, but the addition of the $CaCO_3$ causes an extremely strong mortar, testing well over 125% compared with mortars of standard Ottawa sand of similar proportioning. These sands and gravels are from kame deposits and are of glacial origin, the calcium carbonate being derived from particles of calcite schist from the schist areas to the north. Not only is there much of this schist among the stones composing the gravel, but the gravel itself is strongly cemented. It was necessary to break it up before making briquettes, and on account of this artificial grading of sizes no sieve analysis was made.



FIGS. 1 AND 2. MICRO-PHOTOGRAPHS OF CONCORD SAND (NO. 21) AND PORTSMOUTH SAND (NO. 40)

Left—(No. 21) Showing uniformity of sizes and presence of nothing but quartz fragments. Right (No. 40)—Showing similarity of sizes to Concord sand. White particles are mostly quartz, dark particles hornblende and basalt. Dark particle in center is only limonite fragment in photograph

The fact that the conditions under which the tests were made were fairly uniform is shown by computing the probable error of the means by the methods of least squares. From these computations the probable error of the mean of fifty-two 7-day tensile tests on 1:3 standard sand (Ottawa) mortars was ±2.476 lb., or 1.35%, and that of fifty-four 28-day tests was ±3.82 lb., or 1.64%.

*Field Assistant in Surveying, Thayer School of Civil Engineering, Hanover, N. H.

[1]Condensed from a thesis presented for the degree of Civil Engineer, in April, 1915, to the Thayer School of Civil Engineering, Dartmouth College.

Worcester Road Congress

The so-called International Road Congress held in Worcester, Mass., Dec. 14 to 17, under the auspices of the Worcester Chamber of Commerce, was a notable gathering of New England road officials. The attendance was about 1,000, and several papers of interest to engineers were read. These will be published in full by the Worcester Chamber of Commerce through the secretary of the congress, Herbert N. Davison.

One of the most notable papers was that of William E. McClintock, on "The History of Highway Development in Massachusetts." Mr. McClintock was for many years Chairman of the Massachusetts Highway Commission, and his paper is a valuable collection of reminiscences and early experience in state-road building. This state enjoys the distinction of being about the only one which has followed a consistent policy in state-road building for over 20 yr., and the material Mr. McClintock has put on record will be much sought by future historians and investigators of this present remarkable period of road building.

Papers of general interest were those of Logan Waller Page, Director of the United States Office of Public Roads and Rural Engineering, on "What the United States Is Doing for the Good Roads Movement," and W. A. McLean, Engineer of Highways, Department of Public Works, Province of Ontario, on "The Development of Improved Highways in Canada and What It Means to the Dominion." Mr. Page's paper was largely a discussion of the economics of road construction, and that of Mr. McLean dealt largely with organization and ac-

complishments of the highway departments of the Canadian provinces.

The general subject of road-building materials was discussed in papers by W. W. Crosby, Consulting Engineer, Baltimore, Md., and Dr. Joseph Hyde Pratt, State Geologist of North Carolina. A debate on the relative merits of natural and refined asphalt, which was scheduled to take place between Clifford Richardson, of the Barber Asphalt Co., and Leroy M. Law, of the United States Asphalt Refining Co., did not take place as Mr. Law was the only one of the contestants present. His paper on "The Merits of Refined Asphalt Roads" gave a very good summary of what has been accomplished with the use of the petroleum asphalts, particularly those from Mexico.

City street pavements were treated in papers by George W. Tillson, Consulting Engineer of the Borough of Brooklyn, N. Y., and Henry Welles Durham, Consulting Engineer, New York City. Mr. Tillson went on record as favoring a sand cushion rather than a mortar bed for stone-block and brick pavements. He considers the sand bed necessary for resiliency and holds that the mortar bed will result in a more noisy pavement. Mr. Durham's paper gave an excellent summary of the history of granite-block pavement and of the improvements in practice in this country and abroad.

The financing of street improvements was the subject of an excellent address by Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment, New York City. Some very convincing arguments were presented to establish the fallacy of long-term bonds for temporary improvements. He believes that a large proportion of the cost of street improvements in the great cities should be borne by local property which is directly benefited—in other words, the public should obtain its just part in the unearned increment on real estate.

The paper of W. H. Connell, Chief of the Bureau of Highways, Philadelphia, Penn., on "The Organization of Highway Departments," was chiefly a description of a system for keeping in touch with the many street jobs under way, conditions of pavement, etc., in a great city, by the use of wall maps and colored pins. With the help of combinations of these pins and the use of a visible card index the chief of the bureau is able to answer promptly all ordinary inquiries as to the status of the work, condition of the pavement, etc.

The concrete roads of Milwaukee County, Wisconsin, the methods of construction, maintenance and other essentials, were the subject of a paper by Herbert J. Kuelling, County Highway Commissioner. Concrete, and steel and concrete highway bridges were discussed in a paper by J. R. Worcester, Consulting Engineer, Boston, Mass.

A paper of considerable interest to engineers was that of Edwin Duffey, Commissioner of Highways of New York State. Mr. Duffey stated that under his administration the New York State Highway Department is reverting largely to the construction of waterbound macadam roads—more miles of this type are now under construction in New York than of any other one type. He seemed to consider the experience with bituminous macadam unsatisfactory. He spoke favorably of concrete pavements, the standard width for which his department has made 17 ft. He thought conservatism should be the rule of the department, which now has $22,000,000 worth of work under way.

The other papers covered a variety of subjects from the automobile and horse owners' point of view. There were numerous entertainments and an exhibit of road-building materials and machinery. A registration fee of $3 was charged each of the delegates except those who had a part in the program.

Maintenance and Repair of Concrete Pavements

Milwaukee County, Wisconsin, has adopted concrete pavement almost exclusively for road surfacing. Of this type of construction 40,000 sq.yd. was built in 1912; 218,000 sq.yd. in 1913; 264,000 sq.yd. in 1914; 399,000 sq.yd. in 1915, and about 350,000 sq.yd. will be built during the coming year. All these pavements are 16 or 18 ft. wide, 8 in. thick in the middle and 6 in. thick at the sides. The following notes on the maintenance and repair of these pavements are from a paper by Herbert J. Kuelling, Highway Commissioner, Milwaukee, Wis., read Dec. 16 at the Worcester, Mass., Road Congress.

The best method of repairing small depressions is to first sweep the pavement surface with a steel broom to loosen any dirt; after which the spot is thoroughly swept with fiber street-cleaning brooms and finally with ordinary house brooms to remove all dust and dirt possible. The depression is then covered with hot Tarvia-X and covered with coarse sand or screenings, after which it may be opened to traffic.

If the depressions are of considerable depth, one of two methods may be employed. The depression is cleaned as already described, then tar painted and brought to grade with crushed stone. Care must be taken not to have stone larger in size than the depth of the depression. The stone is tamped in place with hand tampers or with a road roller The voids in the tamped stone are then filled with a bituminous binder, allowing about 1 gal. per sq.yd. per in. of depth. This is the quickest way to make repairs and prevents interruption to traffic for any length of time. The second method is to cut out the poor place entirely and after trimming the sides of the hole and thoroughly sprinkling the surrounding concrete with water, to fill the hole with new concrete of the same mixture as the original road.

In Milwaukee County it has been found economical to have a small maintenance crew, consisting of a foreman and four laborers with a team and wagon, go over all the roads once or twice each year. This maintenance crew under average conditions fills all cracks, bad joints and small pits in from 1 to 2 mi. of 18-ft. concrete pavement per day, at a cost of from $15 to $30 per mi. for labor and materials.

An experiment has been tried of treating the entire surface of some pavements with from ⅓ to ¼ gal. of tar per sq.yd., applied with a power spraying device. Care is of course taken to have the surface thoroughly clean. If a second application is made, asphalt may be used instead of tar, as it has been found the asphalt will adhere to the tar where it will not adhere to the original concrete surface. These experiments have not yet progressed far enough to warrant any conclusions, but Mr. Kuelling seemed convinced that a successful means of treating concrete roads in this manner would soon be developed as a result of the work.

News of the Engineering World

Broken Wires Caused the New Haven Railroad Blockade

The complete interruption of traffic on the Woodlawn-New Haven electric-traction zone of the New York, New Haven & Hartford R.R. during the storm of Dec. 13 and 14 (as described in *Engineering News*, Dec. 16) and the crippled condition of the road for several days thereafter appear to have been due entirely to broken signal and feeder wires. There seems to have been no other part of the electric-traction equipment in serious trouble. A casual inspection of the zone just after the storm (by observation from approaches to the right-of-way and from the rear end of one of the early trains) showed innumerable breaks of the auxiliary circuits along the 60-mi. stretch—and but little else. The catenary overhead contact system was undisturbed, the only trouble apparent being a few loose hangers between messenger cable and running wire at one point—due probably to arcing of a locomotive pantograph at ice barriers. No catenary bridges were damaged, and none of the short masts holding the signal and feeder wires above these bridges showed trouble—beyond three cases of bent cross-arms. There were many broken insulators but no plain evidence of whether these failed first or as the result of unbalanced pull as the wire spans snapped under their ice load.

Liquid Chlorine Adopted by Minneapolis Water-Works

Minneapolis has added its name to the rapidly growing list of cities that have substituted liquid chlorine for hypochlorite of lime to disinfect their water-supply. The change was recommended in November, 1915, by F. W. Cappelen, city engineer. A contract was promptly let to Wallace & Tiernan, New York City, for the installation of three liquid-chlorine outfits with a capacity to treat 60,000,000 gal. a day each. The contract price was $2,000. The apparatus is of the solution-feed manual-control type, similar to that at Buffalo.

The arrangement of the new filtration plant necessitated three units, duplicate machines for regular service and a third in another part of the plant for use in the event of an emergency making it necessary to cut off the clear-water reservoir and resort to direct pumping. A 0.15 solution, or 1 part per million, is being used. The officials believe the the cost will be about 10c. per 1,000,000 gal., or only one-fourth that of the "hypo" process at the last price paid. L. I. Birdsall is superintendent of filtration. The liquid chlorine is being obtained from the Niagara Falls plant of the Electro-Bleaching Gas Co., New York City.

City Engineer Cappelen began his investigation when the war demand sent hypochlorite prices soaring, and Huron, S. D., and other cities in the Northwest began inquiring whether Minneapolis would take care of their needs temporarily should their supplies be shut off.

Huge Steam-Power Plant for Pittsburgh District

A 200,000-kw. steam-electric power station will immediately be erected at Windsor, W. Va. (between Wellsburg and Wheeling on the Ohio River), by the American Gas and Electric Co., of New York City, a concern having plants at Atlantic City, N. J.; Wheeling, W. Va.; Scranton, Penn.; Canton, Newark, Tremont, Mt. Vernon, Pastoria, New Lexington, Lancaster and Tiffin, Ohio; Elwood, Alexandria, Marion and Muncie, Ind.; and Rockford, Ill. This will be a wholesale station to supply the other plants of the company and will also sell large blocks of power to street railways, manufacturers and other electric companies.

The initial installation will be two 30,000-kw. turbine units, and this will be added to until 200,000 kw. is reached. The present aggregate capacity of the company's generating plant is 80,000 kw. The plant has been designed by Sargent & Lundy, of Chicago. Contracts have been let to the Foundation Co., of New York, for the construction of intake tunnels and building and machinery foundations; it is believed that this company will also secure the contract for the building. The General Electric Co. will furnish the turbines and Babcock & Wilcox the boilers. It is expected that the plant will be ready for operation some time in 1916. A contract has been made with a neighboring mine to supply the fuel requirements of the entire plant for the next 45 years. A double-circuit heavy steel-tower line will be at once constructed to Canton and operated at 140,000 volts. Connection will also be made with the company's present system at Wheeling and Newark.

A local business will be developed by the company, inducements being offered to consumers with high load factors. A large acreage was secured by the company in buying land for its station, and this will be sold at moderate prices to desirable customers. Local service will be given at 11,000 volts.

Water-Filtration Experiences

A notable series of papers and discussions on the general subject of "Filter Troubles" was presented at the meeting of the New York Section of the American Water-Works Association on Dec. 16. The main papers were: "Resanding Problems at Albany," by G. E. Willcomb; "Iron Removal by Rapid Sand Filtration," by F. E. Hale; and "Airbound Difficulties at Wilmington, Del.," by E. M. Hoopes. In addition less formal papers or talks by F. W. Greea, G. R. Spalding, E. G. Manahan, S. M. Van Loan and A. A. Tolson were scheduled.

The airbound filter difficulties at Wilmington, described by Mr. Hoopes, were caused by cracks in the filter floor separating the slow sand filters from the clear-water reservoir. Air passed from the space above the water in the reservoir up into the filters, resulting at times in serious air binding and making it necessary sometimes to siphon

water off the top of the bed. When these difficulties are at their worst, sole reliance has to be placed on the chlorination of the water.

Mr. Green stated that in studying red-water difficulties at the Little Falls plant of the East Jersey Water Co. he had been working on the carbonic-acid theory and had added lime to the water to neutralize the carbonic acid. Experiments are now being made with an electrolytic process which he did not wish to describe, as it is proposed to patent it. Oiling ditches to prevent mosquito breeding in the meadows forming a part of the Passaic River drainage area, from which the Little Falls plant takes its water, has at times given some trouble at the filter plant. When rains come and the ditches are overflowed, washing out the oil, the meadow grass is killed. This increases the organic matter in the water to such an extent that it is not always possible to add as much chlorine as is necessary for disinfecting purposes. Remarks by Mr. Green and later by George A. Johnson were made to the effect that it might prove desirable for water-works plants to install their own apparatus for reducing a disinfecting agent, instead of buying either hypochlorite of lime or liquid chlorine. War prices, particularly as regards hypochlorite, may hasten such action by municipalities. Mr. Johnson went so far as to state that if at the introduction of the use of hypochlorite as much had been known as at present, instead of hypochlorite of lime becoming the vogue, water-works plants would have put in apparatus for producing hypochlorite of sodium from common salt. Just now hypochlorite costs something like $150 a ton, as compared with $20 to $30 a year ago. The liquid-chlorine prices have advanced from 25 to 50% on account of the war.

The destructive effect of alum on the piping of the mechanical-filter plant of the Hackensack Water Co. was described by Mr. Spalding. Brass piping had to be renewed at intervals of a year and a half or two years on account of the destructive action of the alum. The pipes not only leaked, but clogged. Sections were cut out and eventually the pipe had to be renewed. A 2-in. brass pipe lost 17 lb. weight per 12-ft. length within two years or so. A 1½-in. brass pipe decreased in weight from 36 to 26 lb. per 12-ft. length in a period of four years. To meet these troubles bronze-composition pipe with slip-joint fittings was tried, and later copper pipe was used. The copper seems to have stood better than the bronze. The slip joints permit the easy removal of any defective lengths of pipe, besides providing a pipe of uniform thickness all the way.

A Proposed Bond Issue of $7,000,000 for street improvement work will probably be voted on in Pittsburgh, Penn., early in 1916.

A Steel Truss Bridge over the Spokane River at Spokane, Wash., collapsed on Dec. 18 under two passing street cars. Seven persons were killed and 10 injured in the accident. Details are not available as this issue goes to press.

A Drawbridge Accident on the Chicago, Burlington & Quincy R.R. occurred Nov. 27 at Quincy, Ill. A train from St. Louis had stopped at the Mississippi River bridge while the draw was opened to let a vessel pass, and the engineman started without waiting for the hand signal which would have notified him that the bridge was closed. The engine went into the river, leaving the tender and train on the track, and the only damage to the bridge was the knocking off of a small portion of the coping of the pier at the end of the swing span. The engineman and fireman were drowned.

A Large Transverse Testing Machine for the Bureau of Standards is asked for in the report of the United States Secretary of Commerce and Labor. The machine is to be suitable for "testing full-sized plate girders, arches, floor constructions, and similar work."

A Utility Commission in Alberta, Can., was recently created. It will exercise a general supervisory control over all public utilities in the province and also act as an advisory board on municipal improvements involving bond issues. The chairman receives a salary of $7,200, and each of the other members $6,000.

Excavation from the Culebra Slides, at Panama, during the week ending Tuesday, Nov. 23, amounted to 303,850 cu.yd., according to the "Canal Record" of Nov. 24. On Monday, Nov. 22, 48,622 cu.yd. were excavated in 24 hr., the highest record for a day's excavation in the cut. Of the three 15-yd. dipper dredges working at the slide, the highest record for the week was made by the "Cascadas," which excavated 83,205 cu.yd.

The Panama Canal was temporarily opened on Dec. 20 to permit the passage of six small vessels which had been waiting at Panama since the closing of the canal on Sept. 18 because of the slides in Gaillard cut. The slides have been removed only sufficiently to allow these small boats to pass, and the canal will be again closed pending the final clearing of the channel. No prediction is made as to when this will take place.

A Proposed $2,000,000 Sewerage Loan at Milwaukee for carrying on the intercepting-sewer work in that city was recently defeated in the city council. The loan has been included in the budget for 1916 and will come before the council for passage in January. Its passage will require a three-quarters vote of the council. It is stated that the nine Socialist members of the council are opposed not merely to this loan but to the whole sewerage improvement. If the loan fails, progress on the sewerage work will be confined to an outlay of half a million a year, requiring a period of 16 or 17 years instead of 5 or 6 to complete the work.

The Commission Plan of Municipal Government exists in 81 of the 204 cities of the United States estimated to have a population of 30,000 or upward in 1915, according to information collected by the United States Bureau of the Census. These 81 cities are located in 26 states, distributed as follows: 5 in New England; 27 in other northern states east of the Mississippi River; 16 in still other northern states lying between the Mississippi River and the Pacific Coast states; 9 on the Pacific Coast; 24 in the South. New Orleans, with an estimated population of 365,000, is the largest city in which the commission plan has already gone into effect, but on Jan. 1, 1916, the plan will go into effect at Buffalo, which has an estimated population of 460,000. The great majority of the commissions consist of five members, but a few have six or seven, and some have three, and one has four. The salaries paid the commissioners range from $7,000 a year in Birmingham, Ala., to $500 a year in Jackson, Mich., and Springfield, Ohio. The terms of office range from one to four years. The salaries of the mayors in the 123 cities of 30,000 population and upward not under the commission plan range from $15,000 a year for New York to $100 a year for Flint, Mich.

Motor-Car Speed Regulation, based on the weight of the car, was proposed by Rear-Admiral Geo. W. Baird in a recent meeting of the Washington Society of Engineers at Washington, D. C. Rear-Admiral Baird said: "It is not possible to make a speed rule to satisfy everybody, but a rule may be made which will be considered fair to the great majority. Basing a proposed rule on the energy of motion of the automobile, let us take W as the weight of the car in long tons and S as the speed in miles per hour; then we will have the formula, $S = \sqrt{\frac{125}{W}}$, which is empirical but approximately fair. Then taking three examples we will have the following: For a light runabout weighing about 1,200 lb., S = 15.2; for a touring car weighing 1,800 lb., S = 12.5; and for a truck weighing two tons with a load of four tons, S = 4.56. This may be opposed by car builders who will be required to make changes in their gears, and it may be opposed by owners of high-priced and better-made cars which are necessarily heavier, but it is not likely to be opposed by pedestrians."

The New Freight Terminal of the Lehigh Valley R.R., in Buffalo, N. Y., was formally opened on Dec. 15. The terminal consists of a team-track yard and two buildings—a two-story office building, 111x60 ft. in plan, and a fireproof shed, 700x60 ft. The office building contains two storage rooms, one for damaged shipments and the other for perishable freight. Of the 700-ft. length of the shed, 600 ft. is taken up by floor space. There are three sections which have fireproof walls with doors protected by automatic fireproof steel curtains.

An automatic scale is provided every 75 ft. There is a platform on the street side for the convenience of wagons. On the opposite side there is a platform at which 47 cars can be unloaded at once. In the yard there are 13 team-tracks with capacity for 150 cars. Each pair of tracks is divided by a 45-ft. roadway paved with Belgian block. An especially interesting detail is that one of the bumpers, which are of concrete, can be used as an unloading platform for end-door cars. There is a ramp leading to the top of the bumper. Cars can unload onto this bumper from two adjacent tracks. Included in the equipment of the yard is a 40-ton crane. The entire yard will be inclosed by a brick wall. The new passenger terminal of the railroad is being constructed opposite the freight terminal.

PERSONALS

Mr. J. W. Fox has been appointed Valuation Engineer of the Central of Georgia Ry. He succeeds Mr. H. D. Pollard, who recently resigned.

Mr. O. K. Morgan, Office Engineer of the Carolina, Clinchfield & Ohio Ry., at Johnson City, Tenn., has assumed the duties of the late Ward Crosby as Chief Engineer of the road.

Mr. Sledge Tatum, M. Am. Soc. C. E., has been designated Acting Chief Geographer of the United States Geological Survey by Secretary Lane. He will continue to serve also as Geographer in Charge of the Rocky Mountain Division.

Mr. Joseph K. Gannett, Chief Draftsman of the valuation and the grade-crossing-elimination departments of the New York, Chicago & St. Louis R.R., at Cleveland, has accepted the position of Assistant Chief Engineer of the Samuel Austin & Son Co.

Mr. G. W. Rathjens, Assoc. M. Am. Soc. C. E., Chief Engineer of the Twin City Brick Co., of St. Paul, Minn., has been appointed a member of the new Charter Commission of St. Paul. Mr. Rathjens is also President of the Public Affairs Committee of that city.

Mr. Fred C. Alber, Commissioner of City Parks of Cleveland, Ohio, has resigned to become City Manager of Newburgh, N. Y., at a salary of $6,000 a year. Mr. Frank M. Patterson, Secretary to Mr. Alber, will assume his duties as head of the park system until Jan. 1.

Mr. E. L. Dunbar has resigned as Superintendent of the Water Department of Bay City, Mich. He leaves the service on Jan. 1 and will move to Los Angeles, Calif. Mr. Dunbar was the first superintendent of the department and served for 40 years. He will be succeeded by Mr. R. C. Dawson.

Mr. C. H. Fox, formerly Assistant Division Engineer of the Canadian Pacific Ry., at Winnipeg, Man., has been appointed Resident Engineer of District 2, Manitoba division. He succeeds Mr. E. L. Landorph, who has been transferred, and the position of Assistant Division Engineer has been abolished.

Mr. J. M. Dooley, recently Superintendent of the Rio Grande division of the Texas & Pacific Ry., Dallas, Tex., has been promoted to be Superintendent of Transportation of the entire railway. He is succeeded as Division Superintendent by Mr. C. E. McMullen, formerly Trainmaster at New Orleans.

Mr. Charles H. Paul, M. Am. Soc. C. E., formerly Construction Engineer in charge of the Arrowrock dam, has resigned from the United States Reclamation Service to accept a position with the Miami Conservancy District as one of the principal assistants of Mr. Arthur E. Morgan, M. Am. Soc. C. E., of Memphis, Tenn., Chief Engineer of the district.

Mr. F. E. Kurzenknabe, Consulting Engineer of the Louisville & Nashville R.R. and for the past three years Resident Engineer at Lexington in charge of construction of the West End viaduct and design of the company's freight terminals and yards, has resigned to engage in private practice in Lexington, Ky. He has formed a partnership with W. T. Congleton, of that city, under the firm name of the Congleton Construction Co.

Mr. Wm. R. Billings, M. Am. Soc. M. E., is Secretary and Treasurer of the Farmers' Bureau, Inc., 150 Nassau St., New York City. This is a new institution the object of which is to act as purchasing agent for farm and estate owners, and as contracting and consulting engineers for the design and construction of sewage disposal, water-supply, roadway improvement, etc. Mr. Billings graduated from the Worcester Polytechnic Institute in 1871 and for many years was Vice-President of the Alberger Condenser Co.

Mr. H. L. Vercoe has been appointed Special Engineer of the Canadian Northern Ry. Lines West of Port Arthur, Ont.; Mr. W. T. Moodie, formerly Engineer of Maintenance-of-Way, has been appointed Division Engineer of the Central Division; Mr. T. Lucas, formerly Engineer of Maintenance-of-Way West of Winnipeg, has been appointed Lease Engineer of the Lines West of Port Arthur; and Mr. A. T. Fraser, M. Can. Soc. C. E., formerly District Engineer at Edmonton, Alta., has been appointed Division Engineer of the Western division of the road. All have headquarters at Winnipeg, Man.

Mr. Henry Welles Durham, M. Am. Soc. C. E., Consulting Engineer, New York City, has been appointed County Engineer of Bergen County, N. J. Mr. Durham was Chief Engineer of the Bureau of Highways of the Borough of Manhattan, New York City, from 1912 to 1915, previous to which he was Resident Engineer of the Cape Cod Canal. From 1900 to 1904 he was Resident Engineer in charge of municipal improvements in the City of Panama under the Isthmian Canal Commission. He is a graduate of the Columbia School of Mines, class of 1895. Mr. Durham will continue his New York office at 366 Fifth Ave. and his private practice.

Mr. T. W. Ransom, M. Am. Soc. M. E., Consulting Mechanical Engineer of the Board of Public Works of San Francisco, has tendered his resignation to Mr. M. M. O'Shaughnessy, M. Am. Soc. C. E., City Engineer, to take effect on Jan. 1, 1916, in order to return to his former private practice as Consulting Engineer, with offices at 1104 Merchants Exchange Building. For eight years Mr. Ransom has been actively associated with the city engineering department on the design of the high-pressure fire-protection system and on the municipal street-railway system. Previous to his engagement by the city, he was instrumental in perfecting and developing the impulse waterwheel to its present high efficiency; he designed the hoisting works and air-compressor plants of some of the largest mines in California, and was among the first to advocate the construction of bucket gold dredgers of large capacity. He designed the hulls and machinery of a number of towboats and steam schooners plying on the Pacific Coast.

OBITUARY

Frank H. Baillie, Assistant Manager of Sales of the H. K. Porter Co., Pittsburgh, Penn., died on Friday, Dec. 14.

Sam M. Blevins, Commissioner of Public Utilities of Arkansas City, Mo., died at his home, Dec. 14. He was 58 years of age.

Charles K. Olsen, an engineer and contractor of New York City, died at his home in Flushing, L. I., Dec. 11, at 59 years of age. Mr. Olsen was a native of Norway. He was prominent in the civic affairs of Flushing.

Charles D. McKelvey, Chief Inspector of the Railroad Division of the Board of Public Utility Commissioners, former Member of the Finance Commission and Commissioners on the Board of Public Works, of Paterson, N. J., died at his home in Paterson, Dec. 16.

George N. Steinmetz, a contractor on the construction of the Roosevelt Dam, in Arizona, and the Galveston sea wall, died at his home in New York City, Dec. 19, in his fifty-sixth year. He was born in Seagertown, Penn. He retired from active business three years ago.

Kit Colyer, a road contractor well known in the State of Missouri, died at his home in Independence, Mo., Dec. 14, at 52 years of age. He was born in Crab Orchard, Ky., and spent the most of his life in Sweet Springs, Mo. Mr. Colyer, in partnership with his brother Daniel, under the firm name of Colyer Brothers, built many of the roads in Jackson County.

Capt. Jasper Ward Cook, one of the pioneers to engage in the sand-dredging industry in Toledo, Ohio, died at his home in Detroit, Dec. 17, at 80 years of age. In the early '80s Capt. Cook entered into partnership with Capt. Egbert Doville, and for 20 years the firm carried on a dredging business in Toledo, after which Capt. Cook moved to Detroit and followed the same line of business in that city. He retired three years ago.

Rear-Admiral Nicoll Ludlow, U. S. N., retired, an authority on ordnance, died at the Hotel Gotham, New York City, Dec. 16, at 73 years of age. He was born at Riverside, Islip, L. I., and after appointment from New York State to the Naval Academy was graduated in 1863. He had served 19 years at sea and 17 on shore at the time of his retirement in 1899. During his years of service Admiral Ludlow was located at the Brooklyn Navy Yard, was on special duty at New York, inspector of ordnance at the West Point foundry and the Mare Island Navy Yard, San Francisco. In addition he served in the Naval War College and commanded several vessels on the Atlantic station, the last of which was the "Massachusetts." He was a Member of the Naval Retiring Board in 1897 and at one time Governor of the Naval Home, Philadelphia.

ENGINEERING SOCIETIES

COMING MEETINGS

SECOND PAN-AMERICAN SCIENTIFIC CONGRESS.
Dec. 27-Jan. 8. Washington, D. C.

OKLAHOMA SOCIETY OF ENGINEERS.
Dec. 28. Annual meeting in Oklahoma City. Secy., H. V. Hinckley, Oklahoma City, Okla.

AMERICAN CIVIC ASSOCIATION.
Dec. 28-31. Annual convention in Washington, D. C. Secy., R. B. Watrous, Union Trust Bldg., Washington, D. C.

SOCIETY OF CONSTRUCTORS OF FEDERAL BUILDINGS.
Jan. 3-6. Seventh annual convention in Washington, D. C. Secy., C. R. Marsh, Brattleboro, Vt.

ALABAMA ASSOCIATION OF HIGHWAY ENGINEERS.
Jan. 8. Annual meeting in Montgomery. Secy., J. B. Converse, City Engineer, Selma, Ala.

LOUSIANA ENGINEERING SOCIETY.
Jan. 8. Annual meeting in New Orleans. Secy., W. T. Hogg, State Museum Bldg., New Orleans, La.

WESTERN SOCIETY OF ENGINEERS.
Jan. 12. Annual meeting in Chicago. Acting Secy., E. N. Layfield, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF PENNSYLVANIA.
Jan. 14. Annual meeting in Harrisburg. Secy., E. R. Dasher, 30 So. Front St., Harrisburg, Penn.

CENTRAL RAILWAY CLUB.
Jan. 14. Annual meeeting in Buffalo, N. Y. Secy., H. D. Vought, 95 Liberty St., New York City.

WESTERN PAVING BRICK MANUFACTURERS' ASSOCIATION.
Jan. 14-15. Annual meeting in Kansas City, Mo. Secy., G. W. Thurston, 416 Dwight Bldg., Kansas City, Mo.

MONTANA INSTITUTE OF MUNICIPAL ENGINEERS.
Jan. 17-19. Annual meeting at Billings, Mont. Secy., C. C. Widener, Bozeman, Mont.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting in New York City. Secy., C. W. Hunt.

NATIONAL DRAINAGE CONGRESS.
Jan. 19-21. Annual meeting, Cairo, Ill. Vice-Pres., Edmund T. Perkins, First National Bank Building, Chicago, Ill.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Jan. 20-22. Annual convention in Minneapolis. Secy., Alvin E. Dodd, 140 West 42nd St., New York City.

National Drainage Congress—The sixth annual meeting will be held at Cairo, Ill., Jan. 19 to 21. The object of the congress is to obtain national legislation for reclamation of swamp lands, flood protection and related subjects. It does not seek help for any individual projects, but seeks to have the Government adopt a general policy for reclamation of the swamp lands as it has done already for the arid lands. In connection with the meeting there will be an exhibition of ditching and dredging machines, and other machinery and appliances relating to drainage work. Edmund T. Perkins, First National Bank Building, Chicago, Ill., is chairman of the committee of arrangements.

Association of American Portland Cement Manufacturers—At the annual meeting held in New York City on Dec. 15 the following officers were elected: President, B. F. Affleck; vice-president, F. W. Kelley; assistant secretary, L. R. Ferguson; treasurer, G. S. Brown. Percy H. Wilson, who has served as secretary for a number of years, resigned, and J. P. Beck was elected general manager of the association. B. F. Affleck, the new president, is president of the Universal Portland Cement Co.

The Wisconsin Highway Commissioners' Association holds its annual meeting at Madison, Wis., at the state Capitol, in connection with the annual state-road school, in the week commencing Jan. 31. The secretary is G. H. Mainwaring, Gotham, Wis.

The American Wood Preservers' Association will hold its twelfth annual convention in Chicago at the Hotel Sherman, Jan. 18 to 20. The effect of the European war on the American timber-treating industry will be discussed from the viewpoints of importers and users of creosote oil.

The San Francisco Association of Members of the American Society of Civil Engineers held its annual meeting on Dec. 17 at the Palace Hotel, San Francisco.

American Institute of Electrical Engineers—The mid-winter convention of the institute will be held in New York City, Feb. 8 and 9. A Pacific Coast convention will be held in Seattle, Wash., some time in 1916, under the auspices of the Seattle section of the institute.

The Municipal Engineers of the City of New York will hold their thirteenth annual dinner at the Hotel McAlpin on Saturday, Jan. 15, at 7 p.m. The secretary is Geo. A. Taber, Engineering Societies Building, New York City.

The Central Electric Railway Association will hold its annual meeting in Dayton, Ohio, at the Hotel Miami, Feb. 24 and 25. A. L. Neereamer, of Indianapolis, Ind., is secretary.

The Wisconsin Electrical Association will hold its next annual convention at Milwaukee, Mar. 16 and 17, with headquarters at the Hotel Pfister. The meeting will be held jointly with the Wisconsin Gas Association, the convention of which begins on Mar. 15. The secretary of the Electrical Association is George Allison, of Milwaukee, Wis.

Washington Society of Engineers—At the annual meeting held at the Cosmos Club on Dec. 15, the members and guests numbered 200. The following officers were elected: President, John C. Hoyt, hydraulic engineer, Geological Survey; vice-president, Albert L. Baldwin; secretary, Frederick W. Albert; treasurer, C. B. Mirick; directors, Elliot Woods, Morris Hacker and T. H. Taliaferro. The society was organized 10 yr. ago, and it now has a membership of 412.

The Central Railway Club will hold its annual meeting in Buffalo on Jan. 4, at the Hotel Statler. Two papers will be presented, one on "Yard Operations," by J. R. Hamilton, terminal trainmaster, Delaware, Lackawanna & Western R.R.; the other on "Modern Roundhouse Methods."

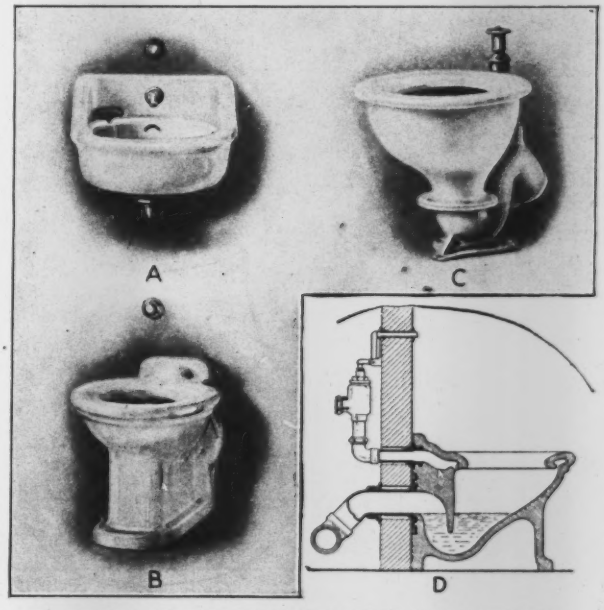
The County Engineers' Association of Yakima, Wash., met in North Yakima on Dec. 2. The officers elected were: President, A. P. Denton; vice-presidents, J. D. Neville and T. J. Wright; secretary, A. L. Strong.

The Indiana Sanitary and Water-Supply Association will hold its ninth annual meeting Feb. 2 to 5 in Indianapolis at the Claypool Hotel. The association meets this year in conjunction with the Indiana Engineering Society, and the program will be continuous, with the program of the association on Feb. 2, and the joint program of the two organizations on Feb. 3 and 4. The engineering society will hold its final session on Dec. 5.

Appliances and Materials

Plumbing Fixtures That Cannot Be Stolen

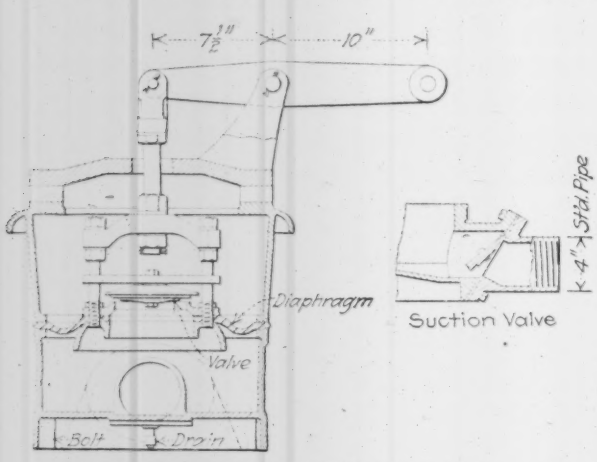
A public-comfort station is not infrequently shut down on account of the surreptitious removal of the brass fittings and lead pipe. The J. L. Mott Iron Works, of New York City, in recognition of this condition has brought out a line of plumbing fixtures the valuable parts of which are concealed from the covetous. Details A and B in combination (see view) are listed at $24.15 to $29.40; the list price for detail C is $17.35. Detail D is a longitudinal cross-section of the closet detail B and shows the concealed flush valve.



PLUMBING FIXTURES WITH CONCEALED FITTINGS

Improvement in Contractors' Pumps

A noteworthy improvement in the design of its contractors' disphragm-type pumps has recently been made by the Harold L. Bond Co., 383 Atlantic Ave., Boston. In working diaphragm pumps by power considerable splashing upon the engine was caused. After experiments with top covers, a



SECTION THROUGH NEW BOND PUMP

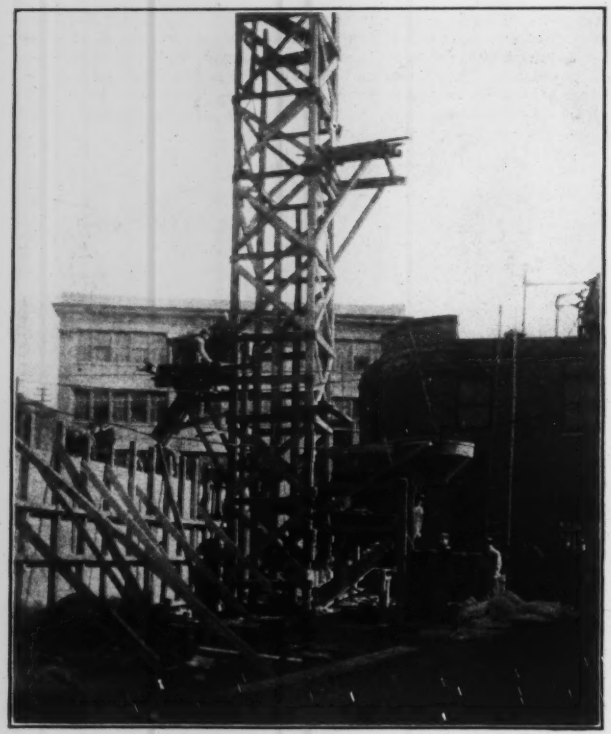
new valve was found successful. It consists of a plate rising vertically and held between two guide bolts by a slotted yoke, as shown in the accompanying figure.

Tests were made on one of the new pumps and a maximum delivery of 189 gal. per min. secured, compared with 100 gal. for the older design run at the same speed.

* * *

New Arrangement of Hains Mixer

Hains automatic mixer equipment is now being furnished for use with elevating towers and chutes. The accompanying view shows a recent outfit made by the Automatic Concrete Mixer Co., of Providence, R. I. The first hopper of the mixer is charged at grade and swung up on an arm to normal discharge position above the second hopper. The hopper may be charged with dry mixture and the water run in after raising the hopper, or the water may be charged at grade. The bottom hopper discharges into a short chute leading to the elevator bucket. The latter automatically tilts into the receiving hopper of the chute. Where there are only two stationary hoppers used below the movable one, the fourth hopper is placed above the chute top instead of a receiving hopper. With three fixed mixing hoppers, the top of the upper one is 12½ ft. above grade.



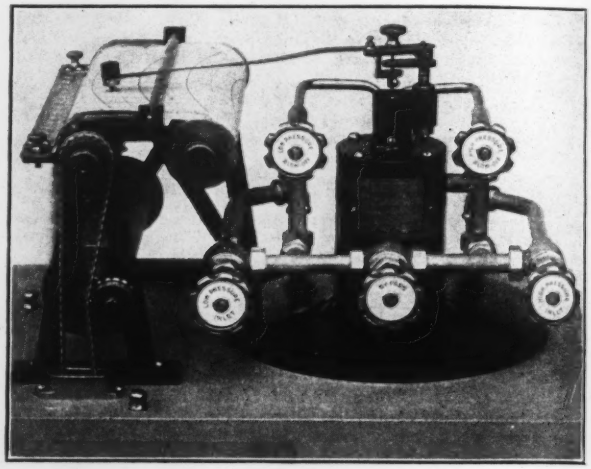
HAINS CONCRETE MIXER ON ELEVATING AND CHUTING TOWER

* * *

Recorder for Pitometers

The continuous meter shown in the view records the variations in flow of water in water mains or other closed conduits and is for use in water-waste surveys and for pump or pumping-station records. A pitometer rod is inserted into the main through a 1-in. cock and its two tubes are connected to pipes in the base of the instrument.

The recorder consists of a collapsible box built up of a series of horizontal hollow corrugated diaphragms in a cylindrical chamber. The upstream and downstream tubes are connected to the interior of the box and the outer chamber respectively. Excess of pressure in the upstream tube, due to the movement or flow of water, causes the box to expand longitudinally (that is vertically). A vertical stem on the box engages a spiral groove on a vertical cylinder,



"DIRECTOGRAPH" RECORDING METER

and this converts the vertical motion of the box to rotary motion of the arm carrying the recording pen. The stem carrying this arm turns on an agate bearing.

The pen traces a line on a ruled chart which passes from a feed roll over a driving roll and down to a take-up roll. Two small rollers between the feed and driving rolls keep the paper level under the pen. The graduation is marked on the chart at 1-ft. intervals, but for greater convenience a scale bar is placed across the paper, as shown. In a dust-proof compartment of the aluminum box which forms the base of the instrument is an eight-day clock movement, with chain drive to the chart rolls. Constant feed is insured by small pins in each end of the driving roll, which engage with perforations in the edges of the chart.

The feed is 1 in. per hour or 2 ft. per day, and the chart is in 65-ft. lengths, or sufficient for a month's record. To examine the chart, the take-up (bottom) roll can be removed and the completed portion of the chart unrolled without affecting the operation of the instrument. The two outer lower valves are for the high- and low-pressure inlets, and the two above are for the respective blowoffs. The middle valve below is for the bypass. The velocity range of the meter is from zero to 12 ft. per sec.

In service the instrument is covered by a sheet-metal case, the locking of which locks the clock chamber, so that there can be no tampering with the operation. The aluminum base has also a chamber for tools, spare parts and charts. The weight complete is about 60 lb.

This instrument is known as the "Directograph" and is the invention of W. R. Brown, of Chicago. In an earlier form it was described in "Engineering News" of Apr. 25, 1912. It is now manufactured by the Municipal Supply Co., 111 West Jackson Boulevard, Chicago.